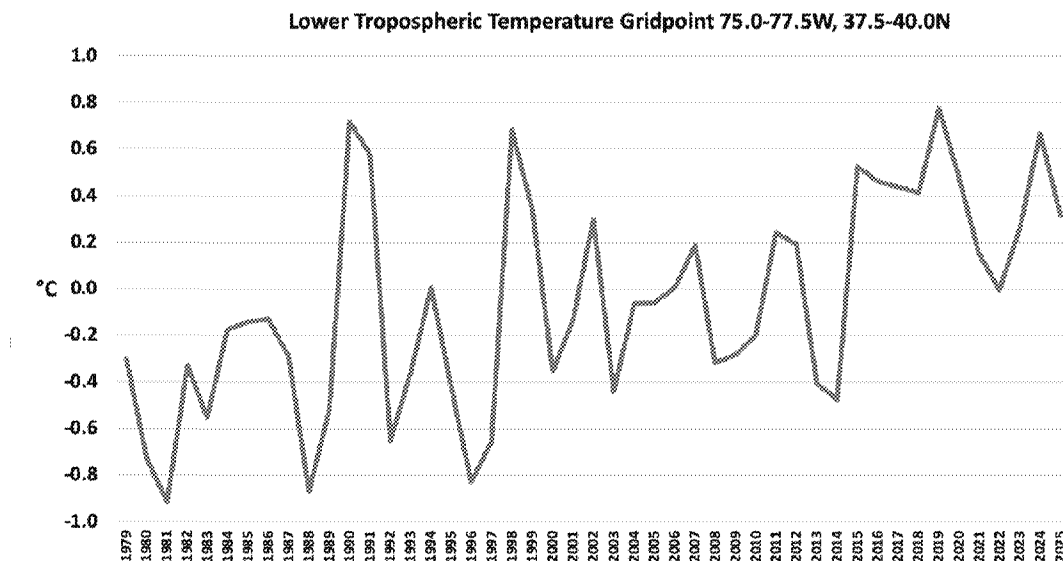


From: John Christy [climateman60@gmail.com]
Sent: 7/21/2025 2:30:19 PM
To: Loucks, Joshua [Joshua.Loucks@hq.doe.gov]
CC: Fisher, Travis [travis.fisher@hq.doe.gov]; roywspencer@hotmail.com; ross.mckittrick@gmail.com; steven.koonin@gmail.com; Cohen, Seth [seth.cohen@hq.doe.gov]; curry.judith@gmail.com
Subject: Re: WaPo article flag

Josh

This is an interesting diagram and I believe demonstrates more of the inconsistencies in the ERA analysis than in actual water loading. Attached is the temperature of the same layer that shows some years tend to be quite warm, but a total average temperature increase over Maryland of +0.9 °C in these 46 years. For example, the total range in temperature is +1.7 °C and in water loading 27% - or 16% per °C. The usual relationship is 7% per °C. Note that peaks around 1990/91 and 1998 in temperature don't correspond with the ERA precipitable water in WPO. Then too, an annual average is not the way to measure water vapor that might impact a particular storm. So, I suspect the ERA analyses has employed various instruments and methods to determine atmospheric water vapor - a very difficult metric to quantify - that have caused inconsistencies over time.

John C.



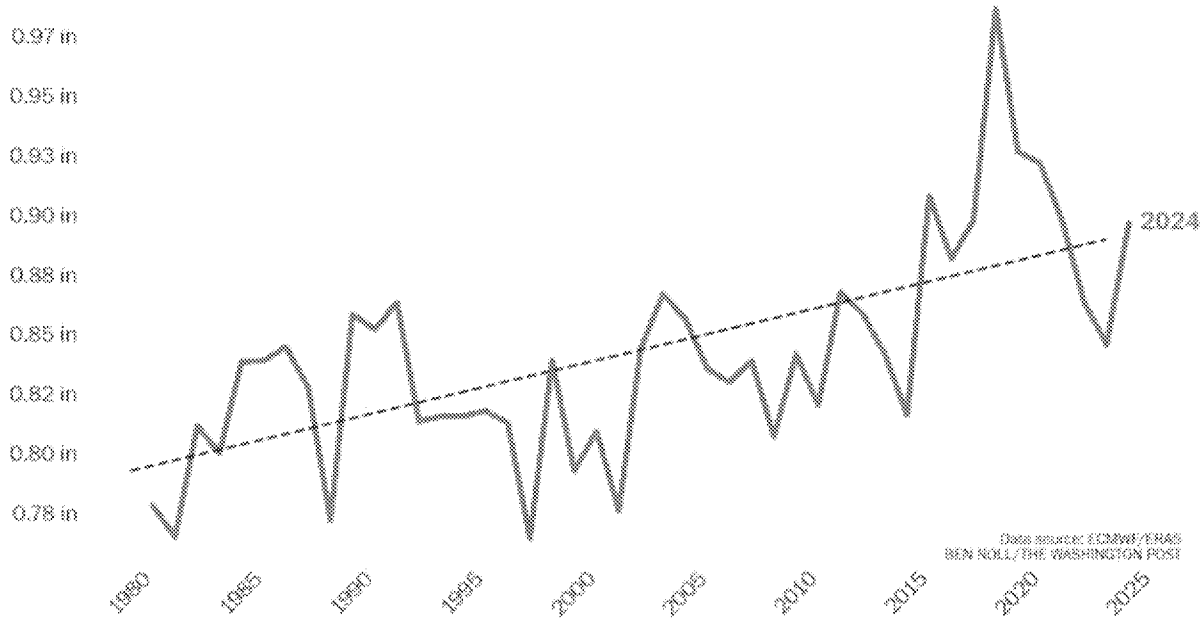
On Mon, Jul 21, 2025 at 8:19 AM Loucks, Joshua <Joshua.Loucks@hq.doe.gov> wrote:

Hi Everyone,

Flagging this article as just another example of the narrative these days.

One thing that stuck out to me, in their final graphic at the end of the article, average atmospheric moisture is conveniently cropped to only show the last 45 years. Link to full article below.

Annual average atmospheric moisture over Maryland



Why the flooding in Silver Spring and the D.C. area was so intense - The Washington Post

Thanks! – Josh



U.S. DEPARTMENT
of **ENERGY**

Follow us on social media

Joshua L. Loucks

Special Assistant

Office of the Deputy Secretary

EMAIL: Joshua.Loucks@hq.doe.gov

OFFICE: 204.961.2098

MOBILE: 518.419.5327

From: John Christy <climateman60@gmail.com>
Sent: Tuesday, July 8, 2025 4:31 PM
To: Ross McKittrick
Cc: Steven Koonin; Travis Fisher; Roy Spencer; Judith Curry; Josh Loucks
Subject: Re: Washington Post on your appointment at DOE

Had the identical CNN email, word for word sent to me.

John C.

On Tue, Jul 8, 2025 at 2:20 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:
And as for the question, if only you'd written a book explaining your views.

On Tue, Jul 8, 2025 at 3:15 PM Steven Koonin <steven.koonin@gmail.com> wrote:
And WaPo weighs in.

Steven E. Koonin

Begin forwarded message:

From: "Spring, Jake" <Jake.Spring@washpost.com>
Date: July 8, 2025 at 15:10:55 EDT
To: steven.koonin@gmail.com
Subject: Washington Post on your appointment at DOE

Dear Dr Koonin,

I'm a reporter with The Washington Post and am wondering if you can confirm your hiring by the DOE? What is the role you'll be taking there? I'm looking to confirm the story on your hiring by New York Times.

Do you agree with your characterization in the NYT? Do you reject the scientific consensus on climate change? Were you brought on to help work on the endangerment finding reconsideration?

If you'd be open to speaking to me, my number is 202 870 0949 and my signal is jspring.99

I'm open to discuss speaking on background if you prefer.

Best,
Jake

Jake Spring
The Washington Post
(202) 870-0949
jake.spring@washpost.com

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Monday, May 19, 2025 10:27 AM
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Judith Curry, President
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Cc: Ross McKittrick; John Christy; Judith Curry; Steve Koonin
Subject: Re: Why are our conclusions so different from those in 2009?

I think you should include both a narrative like Ross's paragraph and a bullet list for chronic skimmers and ADHD journalists.

My only unsolicited advice would be to consider the open-minded folks in the middle (not on your side [yet] but not completely bought into the climate catastrophe narrative either). Maybe I'm projecting my own wishes, so take this with a large grain of salt, but I hope this document attracts plenty of new, curious readers and convinces them to dig into the details themselves.

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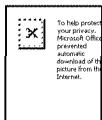
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----- Original message -----

From: Judith Curry <curry.judith@gmail.com>
Date: 5/19/25 2:15 PM (GMT-06:00)
To: Roy Spencer <roywspencer@hotmail.com>
Cc: Travis Fisher <travis.scott.fisher@gmail.com>, Ross McKittrick <ross.mckittrick@gmail.com>, John Christy <climatemanager60@gmail.com>, Steve Koonin <steven.koonin@gmail.com>
Subject: Re: Why are our conclusions so different from those in 2009?

I don't want this report to be about media sound bites. Lets just focus on a clear scientific presentation that is policy relevant

On Mon, May 19, 2025 at 7:36 AM Roy Spencer <roywspencer@hotmail.com> wrote:

I understand the desire for a diplomatic tone, but if you want media outlets to take away details from the report, it will need to be easily understood sound bites, summarizing the major conclusions. I feel like that is still missing from what Ross suggested.

Sent from my Verizon, Samsung Galaxy smartphone

----- Original message -----

From: Travis Fisher <travis.scott.fisher@gmail.com>
Date: 5/19/25 9:27 AM (GMT-06:00)
To: Ross McKittrick <ross.mckittrick@gmail.com>
Cc: Roy Spencer <roywspencer@hotmail.com>, John Christy <climatemanager60@gmail.com>, Judith Curry <curry.judith@gmail.com>, Steve Koonin <steven.koonin@gmail.com>
Subject: Re: Why are our conclusions so different from those in 2009?

This would be a very helpful addition (especially if you use a diplomatic tone--I like Ross's tone here).

For today's meeting, please consider me "on call" if anything comes up that you'd like me to be present for. Otherwise, I'll wait to see the results and try to format quickly behind you all.

If there are chapters that you all feel are close enough to final to be formatted and included in a single document, please let me know, and I can do that while you continue to discuss other chapters.

On Mon, May 19, 2025 at 10:09 AM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

Perhaps as part of the introduction a paragraph along these lines:

In this report we have taken prior assessments by groups like the IPCC and NCA as starting points, and in many cases our conclusions are either the same as theirs or where they offer a range of plausible conclusions we fall within that range. In some places, however, we differ from the IPCC or NCA. In those cases we have gone into some detail to explain the basis of our disagreement. Occasionally we find prior assessments have paid insufficient attention to contrary evidence, and in other cases new research has emerged since earlier assessments that challenges earlier conclusions. In one case, the topic of CO2 fertilization and global greening, we find the IPCC and the NCA have been almost completely silent so we cannot compare our findings to theirs.

I'd like to make it as non-combative as possible and to emphasize for readers that in fact we are positioned well within the mainstream. Some of our critics will be the ones out on the margins.

On Mon, May 19, 2025 at 6:50 AM Roy Spencer <roywspencer@hotmail.com> wrote:

(As a reminder... I will join the meeting this morning as soon as I can).

Virtually none of the critics of our report (journalists, environmental groups, politicians, et al.) will actually read the report. So, they will resort to *ad hominin* attacks and any other non-scientific arguments to discredit what we've produced.

So, I think it might be useful to have a section, maybe just before the introduction, which would be a short list of talking points/sound bites (which we would refer to when we are interviewed) which summarize why our conclusions are so different from those supporting the 2009 Endangerment Finding. (Sorry if something like this is already in the works).

For example (in no particular order):

1. Many of the findings of the 2007 IPCC report relied upon in 2009 were misrepresented
2. The 2007 IPCC report neglected to include opposing scientific opinions
3. There have been many new scientific findings in the last two decades.
4. The future CO2 emissions scenario most relied upon in 2007 is now known to be wildly unrealistic.
5. The rate of global warming has been less than what climate models produce
6. The benefits of increasing CO2 in the atmosphere, as well as of moderating temperatures, have been ignored.

Pithy sound bites will be necessary to build support. There will not be time in interviews (or space in news articles) to go into details.

-Roy

From: Ross McKittrick <ross.mckittrick@gmail.com>

Sent: Sunday, May 18, 2025 10:39 PM

To: John Christy <climateman60@gmail.com>

Cc: Judith Curry <curry.judith@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Steve Koonin <steven.koonin@gmail.com>

Subject: Re: urbanization bias

This would be a good place to make that point. Can you add a few sentences and a reference? Just put them in an email and I can paste it in. As I recall Dick McNider has a good paper on this.

Ross

On Sun, May 18, 2025 at 9:54 PM John Christy <climateman60@gmail.com> wrote:

Ross

Nice summary of how the IPCC ignored evidence. Is this the place to discuss the asymmetric impact of UHI and other aspects?, i.e. TMin much greater than TMax for physical reasons published as early as Oke 1973? Or is this a focussed description of the type of misdirection for which the IPCC is famous?

John C.

John Christy

Director, Earth System Science Center

Professor, Atmos and Earth Science

Alabama State Climatologist

The University of Alabama in Huntsville

climateman60@gmail.com

On May 18, 2025, at 7:59 PM, Judith Curry <curry.judith@gmail.com> wrote:

I like it

On Sun, May 18, 2025 at 5:33 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I added the following material to Ch 3, which we can discuss tomorrow - let me know what you think.

3.1.3 Urbanization

Historical temperature data over land has been collected mainly where people live. This raises the problem of how to filter out non-climatic warming signals due to Urban Heat Islands (UHI) and other changes to the land surface. If they are not removed the data may over-attribute observed warming to greenhouse gases. The IPCC acknowledges that raw temperature data are contaminated with UHI effects but claims to have data cleaning procedures that remove them. It is an open question whether those procedures suffice for the purpose.

The AR6 downplayed the issue by saying (WGI p. 235) that no recent evidence had emerged to alter the AR5 finding that urbanization causes an upward bias of no more than 10% in the global land surface warming trend. The AR5 (WGI p. 189) also cited the 10% upper bound without citing a source. The AR4 (WGI p. 244) cited Jones et al. (1990) and Peterson et al. (1999) as the basis of the claim. Peterson et al. had failed to find any difference in trends between rural and urban samples, although their definition of rural included local populations up to 10,000 persons and the relative influence of urbanization begins well below that (Spencer et al 2025). Jones et al. compared rural/urban warming in three regions: Eastern Australia, Eastern China and Western Soviet Union. Their definition of “rural” included towns of up to 10,000 in the former Soviet Union and up to 100,000 in China. They found relatively warming biases greater than 10% in these areas but conjectured that the urbanization effect averaged over the areas they did not examine would bring the global land bias to under 10% of the observed warming trend.

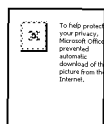
Prior to the IPCC AR4 several papers appeared in print arguing that the warming effect of UHIs added a relatively large (30-50%) component to observed warming and was not simulated by climate models (de Laat and Maurellis 2006, McKittrick and Michaels 2007). These findings were based on correlations between locations of maximum warming over land with locations of maximum socioeconomic development. The AR4 asserted (p. 244) that these correlations were an artefact of natural atmospheric circulations and were in fact statistically insignificant, and on that basis set the findings aside. The claim attracted controversy because it was presented with no supporting evidence. McKittrick (2010) and McKittrick and Nierenberg (2010) showed that taking into account various conjectured alternative explanations for the correlations did not affect their significance. The AR5 (p. 189) conceded that the AR4 had provided “no explicit evidence” for its assessment and further acknowledged, based on these papers, that there was “significant evidence for such contamination of the record” i.e. a warming bias in the land record. However as noted, elsewhere in the report they carried forward the AR4 claim that it was less than 10% of observed warming and they expressed no caution against using the land record for climate measurement on the assumption that it is not contaminated with UHI bias.

Recently Soon et al. (2023) estimated an urbanization bias in the Northern Hemisphere land record over 1850-2018 sufficient to increase the trend in the blended record from 0.55°C to 0.89°C per century. Thus while there is clearly warming in the land record, there is also evidence that it is biased upward by patterns of urbanization and that these biases are not removed by the data processing algorithms used to produce climate data sets. Spencer et al. (2025) propose a new method for measuring UHI biases at local levels using new historical population archives, which may provide a way of further testing for and quantifying the urbanization biases in climate data.

--



Judith Curry, President
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To help protect
your privacy,
Outlook prevented
automatic
download of this
picture from the
Internet.

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<http://www.cfanclimate.net>

From: Roy Spencer <roy.spencer@nsstc.uah.edu>
Sent: Wednesday, July 30, 2025 3:51 PM
To: Randal O'Toole; christy@nsstc.uah.edu; sek9@stern.nyu.edu; curry.judith@yahoo.com; rmckitri@uoguelph.ca
Subject: Re: Wildfire

Hi Randal:

Thank you for the insider info! Could you make a public comment on the report so that we can officially address it? It would be a great help, we want the report to be as accurate as possible.

-Roy

Sent from my Verizon, Samsung Galaxy smartphone
[Get Outlook for Android](#)

From: Randal O'Toole <rot@ti.org>
Sent: Wednesday, July 30, 2025 1:17:12 PM
To: christy@nsstc.uah.edu <christy@nsstc.uah.edu>; sek9@stern.nyu.edu <sek9@stern.nyu.edu>; curry.judith@yahoo.com <curry.judith@yahoo.com>; rmckitri@uoguelph.ca <rmckitri@uoguelph.ca>; roy.spencer@nsstc.uah.edu <roy.spencer@nsstc.uah.edu>
Subject: Wildfire

Hello,

Congratulations on publication of *A Critical Review of Impacts of Greenhouse Gas Emissions on the U.S. Climate*. This deserves to be read by everyone who is concerned about environmental and climate policy.

I am not an expert on climate but I am an expert on wildfire policy. As such, I want to caution you that figure 6.8.3 of your report is based on a lie.

During the 1920s, the Forest Service strongly opposed the use of prescribed fire in the forests. When Congress in 1925 gave the Forest Service funding to assist states in starting fire protection programs, the Forest Service refused to fund any state that allowed for prescribed burning.

Most states in the South therefore refused to join the national fire protection program, and the Forest Service maliciously responded by counting all prescribed fires in those states as wildfires. Since landowners burned most southern pine forests about once every four years, this dramatically increased the number of acres of reported wildfires.

The Forest Service didn't change its policy on prescribed burning until about 1940, and even when it did change its policy it didn't publicly announce the change. Southern states thus stayed out of the federal fire protection program for another decade or so. When they joined, they joined one at a time over about a decade from 1946 to 1956.

Until a state joined, the Forest Service continued to count prescribed fires in that state as wildfires. Thus, the number of acres of wildfires in your chart seems to steadily decline between 1940 and 1955.

This means that the acreage data in figure 6.8.3 are invalid for arguing that wildfires were once more severe than they are today. As I explain in the attached policy brief, it is likely that there were a few more acres burned in real wildfires during the 1930s than in more recent decades, but we can't use those data to prove it.

If you do an updated edition of your report, I urge you to delete figure 6.8.3. While I suspect you are right that climate change is not as serious as others claim it to be, it is just as inappropriate for us to base our arguments on a lie as it is for the other side to do so.

Best wishes,

Randal O'Toole
Thoreau Institute
Camp Sherman, Oregon

From: Judith Curry <curry.judith@gmail.com>
Sent: Sunday, June 22, 2025 12:08 PM
To: Steven Koonin
Cc: Roy Spencer; Ross McKittrick; John Christy; Travis Fisher; Josh Loucks; Cohen, Seth
Subject: Re: write a policy piece?

Interesting idea

We should also think about op-eds, blog posts for circa Jul 13

On Sun, Jun 22, 2025 at 8:29 AM Steven Koonin <steven.koonin@gmail.com> wrote:

Should we collectively author a policy piece to be submitted to, say, Science mag's Policy Forum.

<https://www.science.org/action/doSearch?AllField=policy+forum>

It could be titled something like "Reflections on the National Climate Assessment"

Would they dare publish it? Since our critique will have the status of an official USG document, that might help.

If not Science, then perhaps we could try Issues in Science and Technology?

Steve Koonin

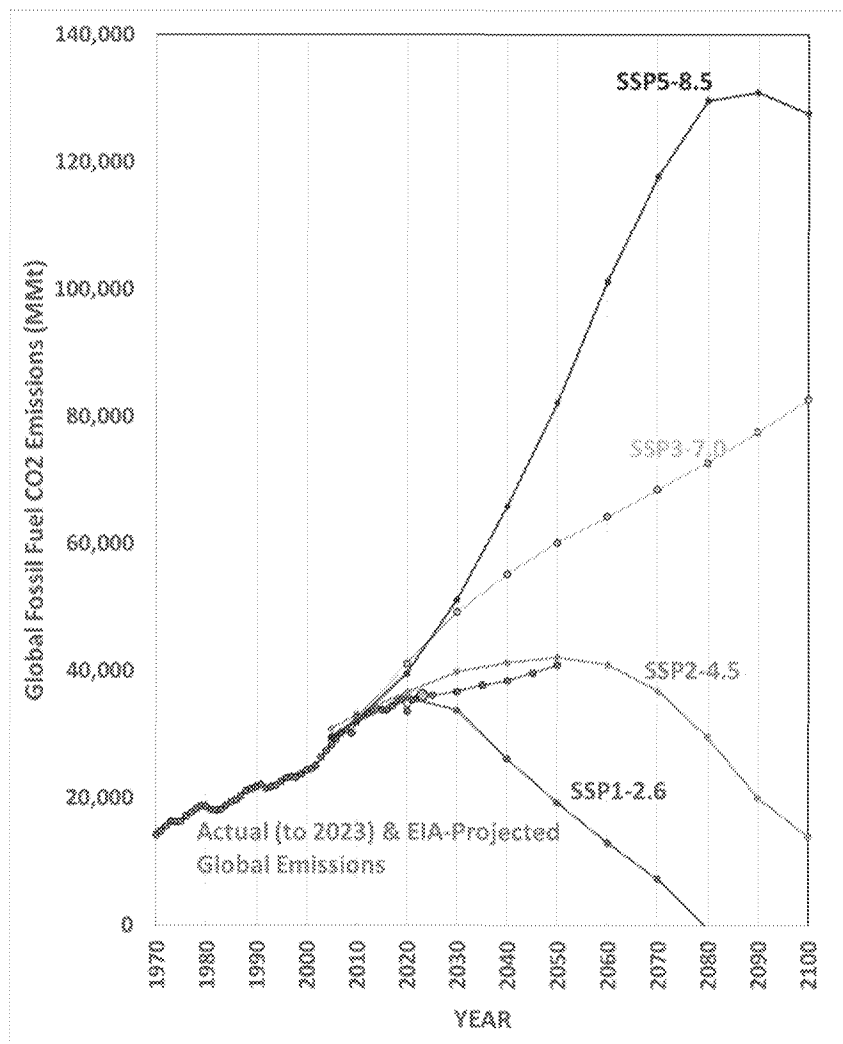
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Judith Curry, President
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<http://www.cfanclimate.net>

From: Roy Spencer [roywspencer@hotmail.com]
Sent: 5/15/2025 10:03:51 AM
To: Travis Fisher [travis.scott.fisher@gmail.com]; Steven Koonin [steven.koonin@gmail.com]
CC: Ross McKittrick [ross.mckittrick@gmail.com]; Judith Curry [curry.judith@cfandclimate.com]; John Christy [climateman60@gmail.com]
Subject: Replacement for Fig. 4.2.1
Attachments: paste.png; ipcc-SSP-scenarios-from-Our-World-In-Data.xlsx

I would like to campaign for the use of the following figure regarding SSP CO2 emissions scenarios vs. actual emissions. I put this together last year using the sources in the attached Excel file, which also has the chart... feel free to reformat it. The most recent global CO2 emissions data are from 2023, which was in a 2024 report.
-Roy



From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Wednesday, May 14, 2025 10:24 PM
To: Steven Koonin <steven.koonin@gmail.com>
Cc: Ross McKittrick <ross.mckittrick@gmail.com>; Judith Curry <curry.judith@cfandclimate.com>; John Christy <climateman60@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>
Subject: Re: New folder: 01.Report Draft

I'm just now seeing this thread after opening Chapter 1 for review. From now on, I'll work from the clean versions.

My one comment on Ch1 is attached.

On Wed, May 14, 2025 at 7:18 PM Steven Koonin <steven.koonin@gmail.com> wrote:
That works. Thanks.

SEK

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Wednesday, May 14, 2025 7:17 PM
To: Steven Koonin <steven.koonin@gmail.com>
Cc: Judith Curry <curry.judith@cfanclimate.com>; John Christy <climateman60@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>
Subject: Re: New folder: 01.Report Draft

This should get you in
https://www.dropbox.com/scl/fo/wahx6lpwzu33m5vyri8x/ANTU1qAQJ-zXCFzP_gsJcOs?rlkey=llz3qj9v46e1t5f4ywwxq7p8c&dl=0

This is for the parent folder. Let me know if it doesn't work.

On Wed, May 14, 2025 at 6:41 PM Steven Koonin <steven.koonin@gmail.com> wrote:

Can you please send a link to the new folder?

Thanks.
Steven E. Koonin

> On May 14, 2025, at 15:27, Ross McKittrick <ross.mckittrick@gmail.com> wrote:

>
>

> Following our meeting today I created a new folder containing clean copies (all past tracked changes accepted) of all chapters.

> There are some marginal queries and in-line comments remaining to be resolved, missing Figure captions in a couple of places etc. If you are able to supply the missing info go ahead and do so. We will soon need to sign off on final text versions so please read through them.

> I propose that these should be the versions we talk through next week.

>

> Question: should there be a single list of references at the very end or should each chapter have its own reference list? Initially I thought the former but now I lean towards the latter.

>

Scenario	Year	Crop demand	Energy crop demand	Livestock demand	Energy crop production	Non-energy crop production
SSP1 - 1.9	2005	3389946625		238986475.6	31469668.7	3417340000
SSP1 - 1.9	2010	3780159000		262440747.1	56039029.3	3813367000
SSP1 - 1.9	2020	4330961000		289096841.8	91136859.74	4354620000
SSP1 - 1.9	2030	4764790750		309853936.5	445930839.8	4944219000
SSP1 - 1.9	2040	5110124250		324523696.3	1574852336	5147676000
SSP1 - 1.9	2050	5455829250		339193526.4	2006291953	5456159000
SSP1 - 1.9	2060	5464465625		332888770.5	2870823938	5464506000
SSP1 - 1.9	2070	5473166625		326584119.1	4050276313	5473212000
SSP1 - 1.9	2080	5481933875		320279377.9	5564746500	5481968000
SSP1 - 1.9	2090	5490764875		313974711.9	6731205375	5490793000
SSP1 - 1.9	2100	5499663000		307670098.6	8014704250	5499687000
SSP1 - 2.6	2005	3389946625		238986475.6	31469668.7	3417340000
SSP1 - 2.6	2010	3780159000		262440747.1	56039029.3	3813367000
SSP1 - 2.6	2020	4330961000		289096841.8	95187658.69	4355897000
SSP1 - 2.6	2030	4764790750		309853936.5	161969332.5	4827157000
SSP1 - 2.6	2040	5110124250		324523696.3	399864022.5	5254736000
SSP1 - 2.6	2050	5455829250		339193526.4	808240431.6	5477702000
SSP1 - 2.6	2060	5464465625		332888770.5	1637018906	5471201000
SSP1 - 2.6	2070	5473166625		326584119.1	2995031625	5479598000
SSP1 - 2.6	2080	5481933875		320279377.9	5202315750	5486188000
SSP1 - 2.6	2090	5490764875		313974711.9	7526928500	5495285000
SSP1 - 2.6	2100	5499663000		307670098.6	7748012625	5509088000
SSP1 - 3.4	2005	3389946625		238986475.6	31469668.7	3417340000
SSP1 - 3.4	2010	3780159000		262440747.1	56039029.3	3813367000
SSP1 - 3.4	2020	4334602375		289174832	109423546.9	4361476000
SSP1 - 3.4	2030	4776535875		310123299.8	215929142.1	4852597000
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SSP1 - 3.4	2050	5485054125		339850246.1	758487498	5519592000
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SSP2 - 4.5	2100	4687290137		401639483.2	6815054091	4979390465
SSP2 - 6.0	2005	2562601266		216129997	0	2734478368
SSP2 - 6.0	2010	2743381807		233117496.4	0	3032884054
SSP2 - 6.0	2020	3251815303		276120344	938601454.5	3544221721
SSP2 - 6.0	2030	3747678810		318008550.7	1029038008	4040308540
SSP2 - 6.0	2040	4176345414		354213553.9	1085571341	4469005322
SSP2 - 6.0	2050	4536363588		383735170.7	1237838008	4829049200
SSP2 - 6.0	2060	4809400776		406764621.9	1790504674	5102106487
SSP2 - 6.0	2070	4986592736		422765346.2	2347505039	5279289678
SSP2 - 6.0	2080	5082883306		432640241.9	2878479130	5375548171
SSP2 - 6.0	2090	5120586811		437128596.9	3357212463	5413196873
SSP2 - 6.0	2100	5070522839		435639160.9	3875204267	5363053826
SSP2 - Base	2005	2562601266		216129997	0	2734478368
SSP2 - Base	2010	2743381807		233117496.4	0	3032884054
SSP2 - Base	2020	3254604910		276592207.6	938601454.5	3547035356
SSP2 - Base	2030	3748450305		318148911.2	1029038008	4041098202
SSP2 - Base	2040	4180407480		354609432.5	1085571341	4473086071
SSP2 - Base	2050	4548648170		384838090.8	1244971341	4841352055
SSP2 - Base	2060	4836569216		409034747.9	1711838008	5129282933
SSP2 - Base	2070	5032566591		426433917.4	2294504674	5325285643
SSP2 - Base	2080	5171049715		439297008.6	2786279130	5463747167
SSP2 - Base	2090	5265445917		447270074.8	3212612463	5558108145
SSP2 - Base	2100	5302376806		451089114.2	3580279131	5594997470
SSP3 - 3.4	2005	2274624100	0	246084000	0	3254988500
SSP3 - 3.4	2010	2638405600	207424500	270010500	0	3546514000
SSP3 - 3.4	2020	3346379800	563275100	317845300	23807300	4124060500
SSP3 - 3.4	2030	4555102100	1586371500	355994500	94732000	4733432700
SSP3 - 3.4	2040	9528768500	7402989100	381268700	1071635300	5301054400
SSP3 - 3.4	2050	1.83E+10	17992488300	401796500	3068492000	5786625400
SSP3 - 3.4	2060	2.5394E+10	26523962900	419259500	4661989800	6222629000
SSP3 - 3.4	2070	3.5933E+10	39375695900	434614600	7167183100	6600240800
SSP3 - 3.4	2080	4.2857E+10	47720115000	449019900	8802562900	6930666100
SSP3 - 3.4	2090	4.8456E+10	54416968000	461911900	10140013100	7225136600
SSP3 - 3.4	2100	5.254E+10	59214813000	473973200	11122271200	7506876700
SSP3 - 4.5	2005	2274624100	0	246084000	0	3254988500

SSP3 - 4.5	2010	2638405600	207424500	270010500	0	3546514000
SSP3 - 4.5	2020	3346379800	563275100	317845300	23807300	4124060500
SSP3 - 4.5	2030	4334357800	1308262100	356197800	78865500	4696965700
SSP3 - 4.5	2040	7100780500	4357552800	383253300	569242400	5207008600
SSP3 - 4.5	2050	1.426E+10	12924807400	405031800	2149181000	5708250500
SSP3 - 4.5	2060	2.4894E+10	25872437300	422248000	4568162000	6213920600
SSP3 - 4.5	2070	2.8874E+10	30511765800	439808400	5402502400	6623522300
SSP3 - 4.5	2080	3.4127E+10	36738348000	456706400	6607696600	6984669600
SSP3 - 4.5	2090	3.9657E+10	43321945700	471661200	7938064700	7287429600
SSP3 - 4.5	2100	4.6153E+10	51128708300	484256100	9519297300	7575811500
SSP3 - 6.0	2005	2274624100	0	246084000	0	3254988500
SSP3 - 6.0	2010	2638405600	207424500	270010500	0	3546514000
SSP3 - 6.0	2020	3346379800	563275100	317845300	23807300	4124060500
SSP3 - 6.0	2030	4322101800	1292808800	356208900	77975800	4694950500
SSP3 - 6.0	2040	6725491200	3885274800	383866700	495259600	5191114100
SSP3 - 6.0	2050	1.2536E+10	10763098200	406531800	1756074100	5676127200
SSP3 - 6.0	2060	1.884E+10	18285814500	426101500	3148049600	6131327800
SSP3 - 6.0	2070	2.5992E+10	26873695300	444496000	4760068500	6571400300
SSP3 - 6.0	2080	3.0861E+10	32607824600	462349700	5824427100	6985566500
SSP3 - 6.0	2090	3.4918E+10	37324825400	479432700	6713919300	7378238300
SSP3 - 6.0	2100	4.0564E+10	44021687900	495667000	8013229100	7769912000
SSP3 - Base	2005	2274624100	0	246084000	0	3254988500
SSP3 - Base	2010	2639070000	208276400	270004500	0	3546642500
SSP3 - Base	2020	3331128200	543713500	317867200	22811500	4121289300
SSP3 - Base	2030	4221368300	1165691900	356336400	59736300	4688856900
SSP3 - Base	2040	5306526100	2108307500	384612200	147776500	5187355300
SSP3 - Base	2050	6859370600	3665047700	408098000	346547600	5663504100
SSP3 - Base	2060	8613413500	5505120900	428164000	610618400	6099001000
SSP3 - Base	2070	1.057E+10	7601542900	447496900	950184300	6502512900
SSP3 - Base	2080	1.2466E+10	9614233500	466442000	1299555400	6887710300
SSP3 - Base	2090	1.3999E+10	11167458400	484770400	1579741300	7260640500
SSP3 - Base	2100	1.581E+10	13059988700	502721500	1932907900	7639074400
SSP4 - 2.6	2005					
SSP4 - 2.6	2010	3256111096	1395044483	193120081.3	0	3480772607
SSP4 - 2.6	2020	3688065943	2055162772	226782507.4	416119337.7	3733450529
SSP4 - 2.6	2030	4056775148	4258197145	249934204.3	1415325744	4106028838
SSP4 - 2.6	2040	4337267449	5901712417	268136529.4	2632015002	4390872346
SSP4 - 2.6	2050	4536958025	7638197466	282536393.6	3811926627	4618779235
SSP4 - 2.6	2060	4621558929	10530066280	287200487.6	5839342348	4791391396
SSP4 - 2.6	2070	4631168732	13720115300	286203612.4	7744104124	4919074582
SSP4 - 2.6	2080	4574436826	16720568310	280748814.5	9427417241	4823136164
SSP4 - 2.6	2090	4460587084	19412784120	270089955.8	10794232500	4507491963
SSP4 - 2.6	2100	4320295803	23382926660	257851582.8	11875246740	4339484585
SSP4 - 3.4	2005					
SSP4 - 3.4	2010	3256111096	1395044483	193120081.3	0	3480772608
SSP4 - 3.4	2020	3688065943	2055162772	226782507.4	416119349.5	3733450818
SSP4 - 3.4	2030	4065408416	3463103048	251364275.2	809967869.6	4111201746

SSP4 - 3.4	2040	4366079065	4499070945	271523728.1	1401410885	4411540553
SSP4 - 3.4	2050	4599917934	5460304167	288599036.2	2030468052	4649384202
SSP4 - 3.4	2060	4717078697	7157216458	295632702.3	3319492453	4790891641
SSP4 - 3.4	2070	4764389428	9439653165	297221030.5	4981006890	4901687526
SSP4 - 3.4	2080	4743325249	12504323010	293813742.2	7006761445	4998394008
SSP4 - 3.4	2090	4640694514	15652634050	284739256.4	8872495698	4950759336
SSP4 - 3.4	2100	4520489840	18310555540	273574855.9	10415977160	4656175021
SSP4 - 4.5	2005					
SSP4 - 4.5	2010	3256111096	1395044483	193120081.3	0	3480772608
SSP4 - 4.5	2020	3688065943	2055162772	226782507.4	416119349.5	3733450818
SSP4 - 4.5	2030	4069388299	3134398163	252019096.3	694478796.2	4114065334
SSP4 - 4.5	2040	4379321638	4069379209	273209268.5	1026342599	4423510300
SSP4 - 4.5	2050	4631730624	4764042079	291829345.3	1439663950	4676678990
SSP4 - 4.5	2060	4768264870	5779588519	300213929.5	2191441997	4821543573
SSP4 - 4.5	2070	4840582218	7101882306	303464075.8	3189633018	4917135902
SSP4 - 4.5	2080	4919420978	7667474162	307518762.8	3603229438	5022206403
SSP4 - 4.5	2090	4940141114	8004922179	306890861.3	3861042914	5063430600
SSP4 - 4.5	2100	4921290329	8938689741	303336930	4582757083	5083913288
SSP4 - 6.0	2005					
SSP4 - 6.0	2010	3256111096	1395044483	193120081.3	0	3480772608
SSP4 - 6.0	2020	3688065943	2055162772	226782507.4	416119349.5	3733450818
SSP4 - 6.0	2030	4075308094	2719598698	252973984.1	575134101.5	4118197255
SSP4 - 6.0	2040	4400629550	3350646210	275974186.1	747468307.6	4444520472
SSP4 - 6.0	2050	4681811061	3871040683	297647864.3	894189174.5	4726210114
SSP4 - 6.0	2060	4861749764	4462581725	309141212.1	1101942473	4908311613
SSP4 - 6.0	2070	4990659644	4722943634	316251769.1	1228501030	5039111504
SSP4 - 6.0	2080	5075092902	4938958937	319763915.7	1373609897	5126279379
SSP4 - 6.0	2090	5091903767	5132000307	318052955.6	1530004098	5147582389
SSP4 - 6.0	2100	5086261651	5471607722	314753919.2	1819424521	5152509904
SSP4 - Base	2005				0	3097622458
SSP4 - Base	2010				0	3480772608
SSP4 - Base	2020				377877064.1	3731899247
SSP4 - Base	2030				590799514.6	4122075488
SSP4 - Base	2040				794897032.3	4453221493
SSP4 - Base	2050				955881565.5	4749315991
SSP4 - Base	2060				1169169265	4940717374
SSP4 - Base	2070				1246357131	5090665457
SSP4 - Base	2080				1297554051	5205640017
SSP4 - Base	2090				1310590368	5263731014
SSP4 - Base	2100				1310732448	5314130224
SSP5 - 1.9	2005		25325500	205757600	25325500	3327675000
SSP5 - 1.9	2010		11213800	235413800	11213800	3758394200
SSP5 - 1.9	2020		83659900	303699700	83659900	4525046700
SSP5 - 1.9	2030		394567300	382277900	394567300	4953645200
SSP5 - 1.9	2040		5939708200	463265700	5939708200	5364107000
SSP5 - 1.9	2050		15281369200	520819300	15281369200	5828327900
SSP5 - 1.9	2060		17786588100	555408400	17786588100	6174538200

SSP5 - 1.9	2070	19348541000	572768000	19348541000	6417277200
SSP5 - 1.9	2080	20623793500	573378800	20623793500	6451233300
SSP5 - 1.9	2090	20715263700	558313300	20715263700	6365479100
SSP5 - 1.9	2100	20914702600	526916100	20914702600	6159845700
SSP5 - 2.6	2005	25325500	205757500	25325500	3327677400
SSP5 - 2.6	2010	11213800	235444900	11213800	3758809400
SSP5 - 2.6	2020	83659900	304184700	83659900	4527751900
SSP5 - 2.6	2030	129415800	382473000	129415800	4946967800
SSP5 - 2.6	2040	1316341200	460410300	1316341200	5317633100
SSP5 - 2.6	2050	7409837300	515365200	7409837300	5753868500
SSP5 - 2.6	2060	14742592600	548486200	14742592600	6052379200
SSP5 - 2.6	2070	17720538700	566200900	17720538700	6333484500
SSP5 - 2.6	2080	19564870900	569582500	19564870900	6361395800
SSP5 - 2.6	2090	21543209900	557599900	21543209900	6314436100
SSP5 - 2.6	2100	23142312000	530170700	23142312000	6170332500
SSP5 - 3.4	2005	25325500	205757500	25325500	3327677400
SSP5 - 3.4	2010	11213800	235444900	11213800	3758809400
SSP5 - 3.4	2020	83659900	304184700	83659900	4527751900
SSP5 - 3.4	2030	74239100	386507800	74239100	4950724100
SSP5 - 3.4	2040	109734000	460248100	109734000	5335194400
SSP5 - 3.4	2050	1157429900	514826600	1157429900	5716099500
SSP5 - 3.4	2060	5030808100	546835200	5030808100	6003412000
SSP5 - 3.4	2070	9704882200	562247800	9704882200	6179976400
SSP5 - 3.4	2080	14470651000	563882300	14470651000	6239495900
SSP5 - 3.4	2090	18761840600	551415000	18761840600	6211186900
SSP5 - 3.4	2100	19915488200	526742700	19915488200	6163501900
SSP5 - 4.5	2005	25325500	205757500	25325500	3327677400
SSP5 - 4.5	2010	11213800	235444900	11213800	3758809400
SSP5 - 4.5	2020	83659900	304184700	83659900	4527751900
SSP5 - 4.5	2030	150668900	386503200	150668900	4950044500
SSP5 - 4.5	2040	290556700	466501500	290556700	5329383300
SSP5 - 4.5	2050	1161593700	514563500	1161593700	5713119500
SSP5 - 4.5	2060	3640707100	546391600	3640707100	5987242400
SSP5 - 4.5	2070	6093771000	561872000	6093771000	6141264400
SSP5 - 4.5	2080	7813299700	561299700	7813299700	6245597000
SSP5 - 4.5	2090	9197138000	546428900	9197138000	6180184300
SSP5 - 4.5	2100	9364927000	519190000	9364927000	6053412500
SSP5 - 6.0	2005	25325500	205757500	25325500	3327677400
SSP5 - 6.0	2010	11213800	235444900	11213800	3758809400
SSP5 - 6.0	2020	83659900	304184700	83659900	4527751900
SSP5 - 6.0	2030	74863100	386616700	74863100	4949998700
SSP5 - 6.0	2040	68809800	467425800	68809800	5333209800
SSP5 - 6.0	2050	58666700	521808800	58666700	5766910000
SSP5 - 6.0	2060	136672100	556845100	136672100	6059344900
SSP5 - 6.0	2070	240499400	570324700	240499400	6211292400
SSP5 - 6.0	2080	325319900	560996900	325319900	6313681400
SSP5 - 6.0	2090	603295700	545549300	603295700	6299093700

SSP5 - 6.0	2100	1246222200	517856900	1246222200	6174619000
SSP5 - Base	2005	25325500	205757600	25325500	3327675000
SSP5 - Base	2010	11213800	235413800	11213800	3758394200
SSP5 - Base	2020	84564500	304241300	84564500	4523136000
SSP5 - Base	2030	87532000	385223300	87532000	4942283400
SSP5 - Base	2040	66829400	465109600	66829400	5320627700
SSP5 - Base	2050	31205900	517348100	31205900	5759041800
SSP5 - Base	2060	34324900	545685900	34324900	6029989800
SSP5 - Base	2070	23590300	559745300	23590300	6208571100
SSP5 - Base	2080	17276100	558366700	17276100	6308108600
SSP5 - Base	2090	58895100	543481600	58895100	6297922900
SSP5 - Base	2100	189018000	516273100	189018000	6197840500

Livestock production	Carbon price	Methane concentrat ion	CO2 concentrat ion	Nitrous oxide concentration	Economic consumpti on	Economic consumption (\$)	Electricity capacity	Biomass capacity
238986500	0	1753.16	379.85	319.855	34531.7	3.4532E+13	3797.849	66.79926
262440781	0	1812.864	390.5053	323.68957	40443	4.0443E+13	4523.66	80.58772
289096875	0	1812.021	412.142	330.4511	60738.12	6.0738E+13	5775.863	185.2419
309853906	303.6736	1631.172	424.6815	335.06455	94211.73	9.4212E+13	5656.165	223.6486
324523656	546.2075	1449.081	425.5272	337.95418	136888.2	1.3689E+14	8287.41	315.4962
339193531	651.0314	1325.072	420.4756	340.41814	181033.2	1.8103E+14	12255.13	429.8082
332888750	707.6402	1250.522	413.8763	342.5171	220858.8	2.2086E+14	14395.68	577.2766
326584125	652.1972	1212.159	406.7838	344.55001	259777.6	2.5978E+14	14604.41	665.2974
320279438	519.7958	1180.458	398.6285	346.6581	294820.9	2.9482E+14	15802.23	711.3799
313974688	335.337	1149.776	389.0571	348.81946	326094.8	3.2609E+14	16652.92	742.3571
307670063	238.8175	1122.537	377.8966	350.98969	352095.3	3.521E+14	16096.66	823.8782
238986500	0	1753.16	379.85	319.855	34531.7	3.4532E+13	3797.849	66.79926
262440781	0	1812.864	390.5053	323.68957	40443	4.0443E+13	4523.677	77.9239
289096875	8.815058	1825.457	414.5497	330.53829	60738.12	6.0738E+13	5988.858	98.95163
309853906	32.72195	1682.249	436.5426	335.65605	94211.73	9.4212E+13	7658.348	97.17514
324523656	71.76319	1519.876	452.2906	339.02523	136888.2	1.3689E+14	9966.742	119.6849
339193531	99.9675	1399.942	460.6929	341.45747	181033.2	1.8103E+14	13132.94	239.4739
332888750	109.9755	1323.012	462.9022	343.47673	220858.8	2.2086E+14	15596.44	453.1193
326584125	148.1949	1271.819	460.6425	345.3853	259777.6	2.5978E+14	17002.01	552.336
320279438	242.5839	1218.766	453.8621	347.39661	294820.9	2.9482E+14	17462.69	671.9833
313974688	185.9612	1176.121	443.0907	349.76675	326094.8	3.2609E+14	16869.16	726.1218
307670063	139.7415	1147.289	432.1714	352.18893	352095.3	3.521E+14	18843.58	549.8993
238986500	0	1753.16	379.85	319.855	34531.7	3.4532E+13	3797.849	66.79926
262440781	0	1812.864	390.5053	323.68957	40443	4.0443E+13	4523.683	77.45602
289174781	0.581091	1873.121	415.1411	330.89811	60738.12	6.0738E+13	6059.375	92.20828
310123281	5.429163	1805.508	440.2962	337.18927	94211.73	9.4212E+13	7996.874	83.13839
324986813	16.70841	1655.813	463.8594	341.99197	136888.2	1.3689E+14	10562.71	57.22467
339850250	22.9549	1528.223	484.0237	345.35377	181033.2	1.8103E+14	14482.27	33.87289
333571594	32.80486	1439.063	499.883	347.75557	220858.8	2.2086E+14	17447.77	22.50634
327292813	61.89357	1357.795	510.1736	349.53688	259777.6	2.5978E+14	19605.84	24.61589
321014156	117.0125	1279.19	512.5219	350.96796	294820.9	2.9482E+14	20277.72	128.4759
314735500	137.5331	1213.912	505.941	352.59674	326094.8	3.2609E+14	19201.58	466.705
308456750	109.8531	1173.123	494.1748	354.75319	352095.3	3.521E+14	19081.28	563.5472
238986500	0	1753.16	379.85	319.855	34531.7	3.4532E+13	3797.849	66.79926
262440781	0	1812.864	390.5053	323.68957	40443	4.0443E+13	4523.684	77.38485
289206813	0.555831	1877.987	415.2466	330.92228	60738.12	6.0738E+13	6068.441	91.82623
310242688	0.81623	1840.18	441.2687	337.48254	94211.73	9.4212E+13	8032.07	77.22823
325304500	3.516333	1744.674	467.459	343.16175	136888.2	1.3689E+14	10718.09	42.19052
340366281	3.035026	1653.497	492.6737	348.03006	181033.2	1.8103E+14	14647.24	19.05672

334133469	7.290082	1575.082	516.0629	351.9978	220858.8	2.2086E+14	18031.06	8.565082
327900656	15.59974	1488.02	536.3393	354.80745	259777.6	2.5978E+14	21018.01	9.012983
321667844	29.58919	1394.327	551.1038	356.54991	294820.9	2.9482E+14	22692.61	7.202462
315435063	45.20924	1305.92	559.8281	357.64416	326094.8	3.2609E+14	22780.28	8.170709
309202250	46.74554	1231.064	563.6224	358.4312	352095.3	3.521E+14	21798.34	10.44637
238986500	0	1753.16	379.85	319.855	34531.7	3.4532E+13	3797.849	66.79926
262440781	0	1812.864	390.5053	323.68957	40443	4.0443E+13	4523.684	77.37998
289282281	0	1888.198	415.3473	330.99404	60738.12	6.0738E+13	6069.227	91.68074
310456313	0	1919.771	442.3016	337.94414	94211.73	9.4212E+13	8037.996	78.89134
325796219	0	1935.294	470.4785	344.412	136888.2	1.3689E+14	10769.04	45.04761
341136156	0	1915.28	498.1738	350.15178	181033.2	1.8103E+14	14619.31	20.84762
334972156	0	1864.652	524.9761	355.07787	220858.8	2.2086E+14	18047.77	9.974223
328808188	0	1797.688	550.8283	359.34345	259777.6	2.5978E+14	21290.03	6.351494
322644125	0	1708.398	573.5107	363.0708	294820.9	2.9482E+14	24044.46	2.116298
316480156	0	1610.532	592.2589	366.25585	326094.8	3.2609E+14	24659.91	1.360061
310316094	0	1526.825	608.3543	368.78591	352095.3	3.521E+14	23770.85	1.166945
216129997	0	1753.16	379.85	319.855	29260.07	2.926E+13	3866.032	28.054
233117496	0	1812.864	390.5053	323.68957	35984.91	3.5985E+13	4745.827	39.998
274615832	31.71469	1880.258	414.0699	331.1026	51240.54	5.1241E+13	6202.269	63.524
312901169	95.13056	1810.255	429.8439	338.05493	82756.7	8.2757E+13	9607.534	56.988
320698974	267.5762	1635.095	433.5009	343.70178	114534.2	1.1453E+14	15405.07	33.778
310942612	435.8535	1476.623	430.8554	347.33493	149628.8	1.4963E+14	21595.19	28.509
291049273	709.9594	1363.518	424.585	349.17142	190133.9	1.9013E+14	28366.23	60.037
276707794	1156.449	1280.619	415.4299	349.77779	239875.4	2.3988E+14	36296.04	136.112
261323787	1883.734	1211.112	404.045	349.45018	297032.5	2.9703E+14	43553.5	207.955
244389578	3068.404	1155.015	391.9963	348.55001	366052.7	3.6605E+14	51066.47	209.617
226570798	4998.106	1114.438	380.6867	347.15951	431221.9	4.3122E+14	61611.73	176.198
216129997	0	1753.16	379.85	319.855	29260.07	2.926E+13	3861.915	28.054
233117496	0	1812.864	390.5053	323.68957	35968.52	3.5969E+13	4743.791	41.329
274382410	31.68069	1881.124	413.9484	331.10772	51126.21	5.1126E+13	6211.32	64.994
315811043	41.84239	1855.488	434.8058	338.36295	82718	8.2718E+13	8218.418	53.36
345656412	52.00433	1746.234	449.9244	345.01008	115650.1	1.1565E+14	10848.66	27.736
360684725	84.70958	1606.051	458.165	350.35926	152349.2	1.5235E+14	15167.44	21.779
360853169	137.983	1505.438	459.9349	354.36652	194035.5	1.9404E+14	20526.9	47.155
357231064	224.7597	1444.547	456.4663	357.27174	244657.6	2.4466E+14	27822.45	103.425
346840839	366.1099	1394.917	448.5629	358.88701	302949.5	3.0295E+14	36541.3	151.521
331033308	596.3545	1335.874	438.7988	359.36443	373619.8	3.7362E+14	48156.67	160.496
314039960	971.3986	1275.33	429.0485	359.03906	442937.8	4.4294E+14	62843.83	148.622
216129997	0	1753.16	379.85	319.855	29260.07	2.926E+13	3861.915	28.054
233117496	0	1812.864	390.5053	323.68957	35960.02	3.596E+13	4743.789	41.329
275496712	21.63314	1884.083	414.4386	331.13802	51114.38	5.1114E+13	6192.776	64.964
317292079	20.10046	1890.372	439.2827	338.57833	82767.6	8.2768E+13	7511.445	51.62
350854242	18.56781	1823.353	463.0454	345.72261	115945.3	1.1595E+14	10112.83	26.643
374643895	30.24501	1697.128	483.2405	351.98161	153094.2	1.5309E+14	13602.65	34.703
386990181	49.26593	1589.186	497.4908	357.16312	195123.4	1.9512E+14	18455.56	54.162
392618685	80.249	1526.255	504.2789	361.32583	246434.5	2.4643E+14	23212.07	90.37
392091973	130.7172	1489.05	504.7783	364.17981	305485.3	3.0549E+14	28911.27	116.217

381399373	212.9245	1455.54	500.7113	365.74437	376695.2	3.767E+14	38544.97	134.479
365387690	346.8316	1414.785	494.1501	366.467	447772.1	4.4777E+14	49805.42	153.465
216129997	0	1753.16	379.85	319.855	29260.07	2.926E+13	3861.915	28.054
233117496	0	1812.864	390.5053	323.68957	35957.38	3.5957E+13	4743.784	41.329
275839085	17.74189	1886.886	414.723	331.15308	51111.88	5.1112E+13	6135.799	64.906
317729577	12.65402	1904.956	440.9205	338.65501	82756.4	8.2756E+13	7514.178	51.225
352634669	7.56615	1874.503	468.5304	346.00617	116027.2	1.1603E+14	9811.851	18.232
380686753	12.32447	1789.139	496.0661	352.7215	153329.3	1.5333E+14	12781.51	10.977
399023954	20.07526	1685.763	521.3235	358.63911	195635.7	1.9564E+14	17148.89	17.589
409914104	32.70048	1612.579	542.5851	363.72682	247252.8	2.4725E+14	21999.79	29.181
414819298	53.26563	1564.646	558.1323	367.55064	306723.9	3.0672E+14	26179.14	57.197
411139333	86.7641	1529.2	565.6875	370.03535	378385.4	3.7839E+14	31982.53	89.57
401639483	141.3296	1506.556	566.8592	371.52198	450110.5	4.5011E+14	39926.63	117.91
216129997	0	1753.16	379.85	319.855	29260.07	2.926E+13	3861.915	28.054
233117496	0	1812.864	390.5053	323.68957	35955.99	3.5956E+13	4743.775	41.329
276120344	15.47938	1890.3	414.7737	331.17027	51108.16	5.1108E+13	6130.903	64.921
318008551	8.46162	1927.638	441.8382	338.7274	82723.1	8.2723E+13	7448.995	51.194
354213554	1.44383	1948.519	472.5694	346.23655	116038.7	1.1604E+14	9540.811	27.501
383735171	2.35185	1928.786	506.9615	353.30509	153422.4	1.5342E+14	12205.32	51.415
406764622	3.83092	1874.066	544.0904	359.82147	195810.1	1.9581E+14	16207.55	55.807
422765346	6.24016	1817.103	582.678	365.81451	247571.6	2.4757E+14	21073.49	65.489
432640242	10.16456	1755.77	622.368	370.9661	307438.4	3.0744E+14	25593.41	124.397
437128597	16.557	1692.872	663.0393	375.34096	379774	3.7977E+14	30169.65	162.429
435639161	26.9696	1631.38	704.272	379.21409	452128.5	4.5213E+14	34356.03	224.521
216129997	0	1753.16	379.85	319.855	29260.07	2.926E+13	3861.914	28.054
233117496	0	1812.864	390.5053	323.68957	35949.84	3.595E+13	4744.362	41.329
276592208	0	1898.442	414.7085	331.20346	51099.36	5.1099E+13	6107.277	64.807
318148911	0	1951.761	442.0015	338.96954	82715.8	8.2716E+13	7369.049	51.158
354609433	0	1995.014	474.0147	346.98686	116057.1	1.1606E+14	9344.282	31.535
384838091	0	2022.441	511.3055	354.93155	153434.1	1.5343E+14	11723.14	61.244
409034748	0	2046.626	553.6277	362.71977	195843.8	1.9584E+14	15379.52	58.658
426433917	0	2070.316	600.7577	370.34052	247576.3	2.4758E+14	19987.46	69.37
439297009	0	2081.128	655.1408	377.75383	307536.2	3.0754E+14	23372.61	123.832
447270075	0	2076.744	718.6013	385.17079	379937.4	3.7994E+14	27358.87	167.982
451089114	0	2053.971	789.8492	392.735	452564.8	4.5256E+14	32712.35	220.338
246084000	0	1753.16	379.85	319.855	33809.15	3.3809E+13	3509.874	61.511
270010500	2.4627	1812.864	390.5053	323.68957	37621.01	3.7621E+13	3963.362	61.4859
317845300	15.5657	1947.572	417.0736	331.54097	51123.02	5.1123E+13	4959.581	68.6987
355994500	87.4244	2091.554	447.3265	340.01592	63536.22	6.3536E+13	6067.887	87.2065
381268700	128.3259	2065.384	470.7605	346.96881	70945.76	7.0946E+13	7374.341	380.5091
401796500	184.2533	1884.667	483.42	351.88448	76480	7.648E+13	9163.966	1006.095
419259500	248.1855	1767.598	490.4725	356.89933	80945.33	8.0945E+13	11114.65	1488.789
434614600	409.54	1722.833	492.7602	361.86602	85128.07	8.5128E+13	13831.87	2247.692
449019900	626.8813	1697.964	490.7222	366.56202	88788.92	8.8789E+13	16853.51	2742.318
461911900	883.3675	1686.443	485.8113	371.04304	92315.26	9.2315E+13	20267.65	3162.051
473973200	1167.677	1683.682	479.1328	375.35505	96607.06	9.6607E+13	23927.29	3477.71
246084000	0	1753.16	379.85	319.855	33809.15	3.3809E+13	3509.874	61.511

270010500	2.4627	1812.864	390.5053	323.68957	37621.01	3.7621E+13	3963.362	61.4859
317845300	15.5724	1947.549	417.0741	331.54097	51123.02	5.1123E+13	4959.581	68.6987
356197800	23.4267	2101.869	448.4431	340.19197	63700.27	6.37E+13	6129.82	79.9146
383253300	40.6628	2104.731	477.9609	347.92203	72119.12	7.2119E+13	6937.65	223.0096
405031800	64.5764	1978.413	501.4905	354.08111	78110.31	7.811E+13	8018.881	721.3256
422248000	120.9541	1891.902	517.6443	360.10596	82321.25	8.2321E+13	9859.132	1487.574
439808400	160.1478	1858.469	527.0577	365.97883	87159.24	8.7159E+13	11174.05	1733.021
456706400	212.896	1861.385	533.9179	371.89534	91768.47	9.1768E+13	12916.25	2087.833
471661200	297.6163	1871.741	538.5743	377.71958	96084.15	9.6084E+13	15252.8	2475.149
484256100	446.9148	1872.287	540.1797	383.24781	100482	1.0048E+14	18324.63	2945.424
246084000	0	1753.16	379.85	319.855	33809.15	3.3809E+13	3509.874	61.511
270010500	2.4627	1812.864	390.5053	323.68957	37621.01	3.7621E+13	3963.362	61.4859
317845300	15.5806	1947.541	417.0743	331.54097	51123.02	5.1123E+13	4959.581	68.6987
356208900	19.8577	2103.183	448.5531	340.21418	63709.74	6.371E+13	6144.141	79.1864
383866700	19.9509	2143.032	480.627	348.42214	72494.86	7.2495E+13	7012.652	200.8666
406531800	28.588	2074.852	511.4254	355.60202	78984.87	7.8985E+13	7947.629	596.0419
426101500	28.588	2060.36	542.9487	363.05868	84404.11	8.4404E+13	8835.031	1036.437
444496000	41.052	2087.458	573.5018	370.72911	89674.62	8.9675E+13	9718.766	1546.525
462349700	57.4871	2110.954	599.9446	378.28435	94527.96	9.4528E+13	10912.8	1872.692
479432700	68.734	2143.896	623.1286	385.83276	99638.89	9.9639E+13	12354.12	2141.931
495667000	82.7129	2185.218	645.0564	393.44522	105504	1.055E+14	14109.11	2547.411
246084000		1753.16	379.85	319.855	33809.15	3.3809E+13	3509.874	61.511
270004500		1812.864	390.5053	323.68957	37619.94	3.762E+13	3958.756	61.4885
317867200		1958.352	417.8888	331.73189	51141.04	5.1141E+13	4997.764	68.3768
356336400		2136.883	451.9973	340.94348	63820.12	6.382E+13	6151.372	77.3847
384612200		2314.385	491.2553	350.99258	73023.94	7.3024E+13	7270.561	96.2335
408098000		2478.77	535.2207	361.56127	79955.97	7.9956E+13	8559.191	142.8895
428164000		2634.316	583.6923	372.57319	85600.53	8.5601E+13	9573.995	206.1249
447496900		2785.519	636.942	384.04251	91401.29	9.1401E+13	10537.99	292.5306
466442000		2936.525	695.6742	395.9181	96993.27	9.6993E+13	11555.6	378.8032
484770400		3087.259	760.9923	408.1424	102821	1.0282E+14	12614.94	441.1172
502721500		3238.033	834.3412	420.66149	109425	1.0943E+14	13777.87	524.289
177627720								
193120126	0	1812.864	390.5053	323.68957			4144.848	30.33453
226782499	0	1921.036	415.2453	331.16247			4956.901	54.48332
249935026	69.90315	1940.883	433.1226	338.29319			7028.708	199.7464
268141071	113.8651	1926.957	440.3508	345.23687			9166.479	351.7711
282535985	185.4743	1947.835	444.1231	352.66659			11391.09	542.4349
287181247	302.118	1963.588	445.2066	360.51557			13354.96	728.6418
286189684	492.118	1964.091	442.356	368.70911			15198.07	893.285
280744657	801.6094	1937.045	433.2123	376.95326			16549.98	1062.837
270100951	1305.737	1889.896	417.6145	384.75886			17760.8	1324.284
257931574	2126.906	1841.637	397.1594	391.96667			18831.28	2204.843
177627720								
193120126	0	1812.864	390.5053	323.68957			4144.848	30.33455
226782499	0	1921.036	415.2453	331.16247			4956.901	54.4833
251364608	34.6142	1959.573	438.4117	338.47259			6518.121	110.0375

271523958	56.38304	1970.224	455.5431	345.72203			8319.422	187.9401
288599695	91.84176	1997.525	466.391	353.27912			10221.17	302.1048
295633934	149.6004	2016.221	472.5781	361.08338			12091.92	439.8529
297222474	243.6834	2027.33	476.0988	369.12603			13951.78	615.4754
293815594	396.9357	2017.851	475.603	377.4044			15396.86	777.819
284751538	646.5664	1984.089	468.5495	385.73505			16603.51	925.6869
273645188	1053.186	1935.698	454.8193	393.68536			17731.03	1152.563
177627720								
193120126	0	1812.864	390.5053	323.68957			4144.848	30.33455
226782499	0	1921.036	415.2453	331.16247			4956.901	54.4833
252019242	20.34388	1974.549	440.5192	338.64818			6370.159	95.63851
273209686	33.13803	2005.847	463.4998	346.25932			7935.955	145.885
291830163	53.97845	2043.44	481.6414	354.10516			9569.76	208.0479
300215009	87.92494	2063.284	493.5641	362.05714			11272.62	288.2907
303465522	143.2207	2071.441	500.919	370.07464			13020.66	415.6971
307520497	147.267	2073.759	505.1717	378.27386			13587.94	451.2379
306897898	157.5793	2080.462	508.5128	386.62144			14078.32	489.8371
303384299	201.0655	2089.317	511.8824	394.97277			14880.55	560.0934
177627720								
193120126	0	1812.864	390.5053	323.68957			4144.848	30.33455
226782499	0	1921.036	415.2453	331.16247			4956.901	54.4833
252974249	2.114418	2038.132	443.7189	339.5447			6335.965	84.77068
275974756	3.444164	2159.899	475.6372	349.23327			7604.555	117.7359
297648599	5.610189	2245.016	508.4056	359.19614			8721.818	146.8847
309142476	9.138373	2293.199	540.5294	369.02267			9808.207	170.6041
316252984	14.88548	2314.926	571.1252	378.45966			10828.11	188.9121
319765569	24.24685	2307.729	597.5109	387.34773			11729.7	195.8065
318058340	39.4956	2280.985	617.5458	395.72455			12594.73	193.9123
314795554	64.33409	2249.813	631.4741	403.76233			13500.73	190.5601
177627720	0	1753.16	379.85	319.855			3733.243	20.20767
193120126	0	1812.864	390.5053	323.68957			4144.848	30.33455
226806023	0	1945.321	415.996	331.53214			5044.324	51.8459
253093463	0	2117.301	446.6259	340.42382			6396.628	82.34672
276367922	0	2304.988	482.375	350.4322			7647.878	112.0634
298845781	0	2451.961	520.9601	361.25518			8731.882	137.1466
310854798	0	2554.269	561.3776	372.62274			9722.47	157.7131
319025194	0	2632.626	602.9313	384.30634			10591.25	176.4068
324128626	0	2671.109	643.1318	396.20072			11257.65	184.6751
324630715	0	2675.739	681.1994	408.17059			11766.1	182.7066
324481161	0	2668.365	718.3727	420.18297			12184.82	169.1904
205757600	0	1753.16	379.85	319.855	29680	2.968E+13	3557	23.92
235413800	0	1812.864	390.5053	323.68957	32950	3.295E+13	4176	34.61
303699700	7.333	1904.271	414.9077	331.13662	47109.47	4.7109E+13	5795	45.62
382277900	96.32	1822.309	439.2346	337.69586	69285.84	6.9286E+13	7042	78.22
463265700	348.8	1617.625	454.8986	343.5938	100751.7	1.0075E+14	11450	310.1
520819300	628.6	1475.146	453.7367	350.82057	138836.7	1.3884E+14	21640	457.8
555408400	1204	1386.759	438.6597	358.63934	184923.2	1.8492E+14	34490	535.8

572768000	1724	1335.886	419.4862	365.31553	223917.6	2.2392E+14	47900	626.4
573378800	2904	1300.28	401.9195	371.12852	285116.2	2.8512E+14	62360	721.3
558313300	4681	1264.49	385.7025	376.29198	342716.6	3.4272E+14	76770	759.8
526916100	7464	1222.31	370.1514	380.3818	402916.9	4.0292E+14	87410	755.9
205757500	0	1753.16	379.85	319.855	29680	2.968E+13	3557	23.92
235444900	0	1812.864	390.5053	323.68957	32950	3.295E+13	4176	34.61
304184700	7.333	1904.687	414.8545	331.11989	47109.47	4.7109E+13	5795	45.62
382473000	41.95	1881.677	441.7258	338.0393	70400.51	7.0401E+13	7603	68.05
460410300	143.3	1741.925	467.4384	343.84257	105659.5	1.0566E+14	10100	118.1
515365200	258.4	1601.803	484.0805	349.08025	147340.1	1.4734E+14	15600	110.9
548486200	493.1	1507.179	486.7812	355.04402	194126.2	1.9413E+14	25070	101.9
566200900	704.8	1434.51	477.7632	361.60235	234018	2.3402E+14	37390	114.4
569582500	1193	1365.116	463.0492	367.55417	296318.5	2.9632E+14	52730	184.2
557599900	1938	1295.545	445.6751	372.73883	353321	3.5332E+14	70400	416.5
530170700	3106	1237.088	427.6169	377.31904	413219.6	4.1322E+14	83230	604.6
205757500	0	1753.16	379.85	319.855	29680	2.968E+13	3557	23.92
235444900	0	1812.864	390.5053	323.68957	32950	3.295E+13	4176	34.61
304184700	7.333	1904.7	414.8492	331.11989	47109.47	4.7109E+13	5795	45.62
386507800	23.59	1930.817	442.3492	338.19333	70515.71	7.0516E+13	7844	61.1
460248100	72.53	1857.46	471.4091	344.43327	106576	1.0658E+14	10060	94.89
514826600	131.4	1730.107	496.6991	349.22238	149949.3	1.4995E+14	13840	108.7
546835200	251.7	1615.035	514.7885	352.94863	198225.1	1.9823E+14	20640	93.46
562247800	359.5	1525.964	522.9733	357.10367	238718.4	2.3872E+14	30450	76.8
563882300	607.1	1443.366	520.2652	361.80904	301715.2	3.0172E+14	44230	83.6
551415000	980.8	1358.624	508.3498	366.72618	360220.3	3.6022E+14	61050	208.5
526742700	1570	1278.011	491.476	371.19061	420621.6	4.2062E+14	74990	370.2
205757500	0	1753.16	379.85	319.855	29680	2.968E+13	3557	23.92
235444900	0	1812.864	390.5053	323.68957	32950	3.295E+13	4176	34.61
304184700	7.333	1904.698	414.8458	331.11989	47109.47	4.7109E+13	5795	45.62
386503200	22.29	1933.404	442.5619	338.2332	70566.16	7.0566E+13	7879	69.29
466501500	56.71	1891.892	473.0421	344.67055	106879.8	1.0688E+14	10100	151.1
514563500	92.38	1792.092	502.3879	349.95626	150964.1	1.5096E+14	13380	244.1
546391600	150.5	1673.229	527.4181	353.98335	200536.6	2.0054E+14	18220	252.5
561872000	215.6	1586.78	546.0745	357.56503	242421.1	2.4242E+14	25580	223
561299700	280.8	1518.442	559.1474	360.97849	307817.1	3.0782E+14	35910	153.3
546428900	345.9	1444.797	567.6406	363.92471	369218.9	3.6922E+14	47540	72.64
519190000	411.1	1361.71	573.7102	366.05058	432820.7	4.3282E+14	55870	38.1
205757500	0	1753.16	379.85	319.855	29680	2.968E+13	3557	23.92
235444900	0	1812.864	390.5053	323.68957	32950	3.295E+13	4176	34.61
304184700	7.333	1904.691	414.8542	331.11989	47109.47	4.7109E+13	5795	45.62
386616700	11.72	1970.243	443.9563	338.41985	70638.24	7.0638E+13	7982	60.64
467425800	22.27	2017.185	479.7991	345.45721	107493.4	1.0749E+14	10330	106.7
521808800	36.28	2017.896	520.1116	351.56325	152483.9	1.5248E+14	13130	221.3
556845100	59.1	1950.076	562.3711	356.30627	203070.1	2.0307E+14	16350	387.1
570324700	84.68	1829.418	603.3297	360.09284	245660.7	2.4566E+14	21310	519.2
560996900	110.3	1679.353	640.6846	363.03054	311550.5	3.1155E+14	29390	569.5
545549300	135.9	1541.429	673.4373	365.0222	372638.7	3.7264E+14	39870	553.4

517856900	161.4	1432.861	702.3926	365.88887	436331.5	4.3633E+14	48250	558.4
205757600	0	1753.16	379.85	319.855	29680	2.968E+13	3557	23.92
235413800	0	1812.864	390.5053	323.68957	32950	3.295E+13	4176	34.61
304241300	0	1927.944	417.2487	331.86119	47100	4.71E+13	5814	44.09
385223300	0	2077.052	452.7668	341.05774	70600	7.06E+13	7741	56.02
465109600	0	2305.153	499.6782	350.48212	107700	1.077E+14	10130	92.08
517348100	0	2565.794	559.6919	359.40246	153300	1.533E+14	12780	160.9
545685900	0	2748.008	635.7926	367.47058	204900	2.049E+14	15430	247.9
559745300	0	2821.259	730.0255	374.95656	248400	2.484E+14	18340	352.5
558366700	0	2807.665	841.5202	381.75309	315400	3.154E+14	22280	466.6
543481600	0	2721.972	963.8416	387.79905	376900	3.769E+14	28220	564.8
516273100	0	2598.51	1088.97	392.83192	439900	4.399E+14	35130	638.5

Coal capacity	Concentrated solar capacity	Gas capacity	Geothermal capacity	Hydropower capacity	Nuclear capacity	Offshore wind capacity	Oil capacity	Onshore wind capacity	Other electricity capacity
967.1142	0.408451	1011.006		871.2293	403.097	0.6842	405.4771	58.03196	9.507541
1139.278	1.256	1170.674		1028.111	422.7627	3.1927	434.5956	193.142	11.24127
1089.114	8.269087	1616.254		1314.283	452.0645	19.43807	325.0383	470.4211	16.97595
871.7687	18.59721	1469.245		1430.762	452.4573	51.14825	248.7839	476.0843	27.49336
254.4913	577.3639	1072.343		1729.524	372.9538	467.2583	31.34222	1022.322	87.54459
209.9185	1978.521	1551.947		1820.346	213.9031	900.5343	8.938429	1986.75	136.447
268.0568	3690.9	2139.423		1876.622	184.2755	877.3956	7.83784	2112.915	181.4908
346.0633	5178.58	2639.027		1936	185.4034	655.3264	8.124931	1643.717	225.5976
336.2973	5959.577	2657.411		1990.567	236.2574	777.0181	7.283624	1608.656	270.6856
282.6755	6356.646	2253.057		2050.245	304.9577	930.3728	6.159712	1890.414	316.622
192.8441	6203.701	1886.382		2077.708	305.6004	776.3416	4.787603	1790.889	360.1929
967.1142	0.408451	1011.006		871.2293	403.097	0.6842	405.4771	58.03196	9.507541
1145.203	1.256	1167.242		1028.111	422.7627	3.1927	434.7843	193.142	11.24127
1358.195	6.389296	1672.53		1341.036	448.1711	19.43218	332.0894	445.4367	18.18246
1331.024	72.76783	2399.909		1576.637	453.498	187.5738	259.5569	647.1627	46.37654
1204.439	498.1575	2752.862		1751.807	347.1891	539.5996	136.7585	861.1098	90.33232
921.2822	1814.396	3040.355		1819.31	172.8064	766.6543	13.29367	1383.281	136.3408
741.3165	3648.462	3017.214		1878.782	129.6688	728.8048	3.984897	1987.364	181.4908
878.2613	5434.34	2847.3		1937.316	107.402	781.8494	3.345448	2109.278	226.356
891.9902	6388.975	2601.152		1987.437	117.5619	960.0585	2.673737	1859.289	271.547
806.116	6350.846	2354.686		2035.21	129.6582	907.529	0.981908	1539.682	316.0923
591.6446	7605.267	2397.229		2082.507	143.3619	818.3722	0.854149	1746.18	359.2863
967.1142	0.408451	1011.006		871.2293	403.097	0.6842	405.4771	58.03196	9.507541
1146.435	1.256	1166.455		1028.111	422.7627	3.1927	434.8128	193.142	11.24127
1421.552	5.790864	1683.2		1345.819	447.8269	17.94565	333.4576	444.6097	18.47044
1641.942	31.20054	2612.443		1577.071	442.6673	132.1734	260.0466	634.9364	46.37866
1744.23	198.3817	3375.869		1761.819	318.1085	510.4467	143.0688	886.0544	91.35909
1657.212	839.5912	4099.308		1820.837	140.3747	883.5641	37.39004	1428.04	136.447
1471.734	2455.441	4406.71		1878.782	92.9352	922.4809	11.79861	1732.065	181.4908
1431.351	4782.221	4116.567		1938.363	62.08425	905.1321	4.967896	2153.686	226.5345
1333.285	6509.652	3517.23		1993.917	44.93508	1064.435	2.994906	2328.328	271.3307
1142.411	6642.047	2817.367		2054.18	52.49417	1088.671	1.132294	2101.093	316.612
898.6857	6850.805	2491.775		2102.164	63.37466	953.7917	0.612264	2003.075	361.3211
967.1142	0.408451	1011.006		871.2293	403.097	0.6842	405.4771	58.03196	9.507541
1146.605	1.256	1166.355		1028.111	422.7627	3.1927	434.815	193.142	11.24127
1425.103	5.724216	1689.812		1345.791	447.8122	17.72753	333.5298	444.3717	18.46897
1736.052	25.62778	2611.211		1577.071	441.2135	117.1069	257.7094	624.5008	46.37866
2111.587	124.8312	3484.248		1762.228	311.5723	457.749	138.3481	857.6037	91.40331
2393.073	392.068	4286.645		1820.837	128.0851	834.1014	38.99168	1360.553	136.447

2516.338	1080.582	4807.685		1878.782	76.89836	935.0019	13.57557	1644.444	181.4908
2391.468	3044.718	4848.693		1938.363	39.39815	919.9186	5.80416	1848.747	226.5345
2061.766	5314.862	4533.64		1997.33	16.88613	1020.423	2.90736	2200.557	271.5308
1723.058	6391.279	4181.814		2057.524	22.32142	1144.029	1.453064	2394.093	316.622
1214.296	6688.285	4036.84		2117.105	23.41139	1026.929	0.728066	2376.649	361.6658
967.1142	0.408451	1011.006		871.2293	403.097	0.6842	405.4771	58.03196	9.507541
1146.618	1.256	1166.347		1028.111	422.7627	3.1927	434.8152	193.142	11.24127
1426.399	5.700469	1689.515		1346.035	447.812	17.63592	333.5559	444.2523	18.48137
1757.47	24.32383	2608.681		1577.071	441.0693	112.6597	256.8643	621.1443	46.37866
2208.786	111.5134	3511.657		1762.228	310.2281	439.85	132.2743	855.3053	91.40331
2571.693	328.4404	4310.247		1820.837	126.0087	809.5539	39.43519	1340.192	136.447
2912.966	773.2396	4857.325		1878.782	73.89302	910.8605	13.82658	1591.858	181.4908
3194.92	2013.003	5031.552		1938.363	34.46153	887.9611	5.743623	1777.796	226.5345
3227.006	3982.155	4950.68		1997.943	9.460465	943.8033	2.562412	2044.96	271.5783
3015.137	5309.353	4790.264		2057.524	8.444734	886.9701	1.149439	2195.256	316.622
2533.823	5646.774	4749.764		2117.105	5.751502	752.1234	0.522635	2267.013	361.6658
1208.495	0.3	891.075	9.764	855.358	405.859	0	408.377	55.351	
1553.732	1.731	1065.488	16.075	1127.523	415.13	0	233.178	254.922	
1613.275	1.731	1774.296	14.721	1225.253	510.583	0	87.756	653.669	
1175.07	12.206	2133.945	36.193	1634.296	762.768	73.833	45.119	2108.952	
477.651	56.152	2605.065	112.055	2123.571	1248.415	292.998	18.577	4425.197	
103.439	153.781	2538.66	167.891	2341.763	2243.648	647.958	10.681	6072.239	
38.937	341.217	2270.977	219.476	2555.453	3658.643	868.073	10.285	7724.418	
15.657	658.858	1573.546	270.27	2680.816	4459.27	1183.026	0.645	10058.44	
5.265	1119.525	1480.223	278.07	2749.172	4604.702	1519.714	0.001	12830.54	
1.24	1760.21	1502.834	287.276	2795.207	4151.388	2332.063	0.001	15122.17	
0.03	2706.043	1792.994	295.515	2825.668	3285.822	3479.677	0	17783.77	
1208.581	0.3	886.675	9.761	855.159	405.859	0	408.458	55.668	
1551.226	1.731	1064.809	16.072	1127.334	415.13	0	232.871	255.239	
1615.484	1.731	1773.927	14.718	1225.067	517.699	0	87.774	652.475	
1146.576	1.581	2861.203	8.783	1467.604	705.903	14.726	45.109	1542.215	
481.693	0	4214.792	14.761	1637.852	995.004	82.783	18.924	2433.376	
158.12	11.44	5277.666	25.741	2010.801	1616.659	153.766	10.703	3528.955	
151.718	49.886	5588.482	39.126	2220.299	2527.999	160.448	10.285	4913.721	
140.467	140.368	5506.158	68.915	2460.321	3549.061	194.403	0.645	6696.389	
93.673	309.329	4655.599	143.09	2645.272	4178.811	474.502	0.001	9812.325	
78.942	604.81	4267.885	218.133	2788.212	4476.083	996.11	0.001	14154.4	
65.34	1076.35	3711.095	284.64	2826.235	4275.281	2427.28	0	18583.07	
1208.581	0.3	886.675	9.761	855.159	405.859	0	408.458	55.668	
1551.259	1.731	1064.776	16.072	1127.331	415.13	0	232.871	255.239	
1614.296	1.731	1766.62	14.718	1219.116	517.692	0	87.774	648.413	
1173.583	1.581	2896.461	8.783	1316.548	515.831	0	45.109	1210.556	
486.978	0	4712.235	1.462	1616.08	595.585	0	18.924	2127.393	
124.407	0	6240.346	9.754	1733.223	898.287	0	10.704	3282.19	
120.289	0	7168.648	20.5	2042.709	1612.955	17.357	10.285	4521.637	
122.55	4.176	6780.278	33.588	2250.893	2848.424	26.941	0.645	5616.395	
139.529	30.241	6860.963	58.393	2427.428	3953.613	80.617	0.001	6965.821	

122.709	99.561	6652.435	103.285	2659.684	4638.2	254.855	0.001	10087.95
131.67	234.498	6221.054	187.828	2775.967	5133.383	715.742	0	14373.04
1208.581	0.3	886.675	9.761	855.159	405.859	0	408.458	55.668
1551.258	1.731	1064.78	16.072	1127.322	415.13	0	232.871	255.239
1615.257	1.731	1770.619	14.718	1219.107	517.672	0	87.774	586.564
1203.969	1.581	2957.59	8.392	1299.642	482.919	0	45.109	1197.518
660.908	0	4773.125	1.044	1569.448	453.548	0	18.924	1937.532
443.021	0	6415.364	1.044	1654.466	642.994	0	10.704	2900.356
361.409	0	8169.03	0.625	1757.112	1019.553	0	10.285	4336.712
209.818	0	9245.938	0.625	1913.975	1870.821	0	0.645	5505.533
66.886	0	8678.841	3.676	2219.417	3231.544	6.331	0.001	6338.78
106.755	5.911	6851.948	26.463	2551.319	4973.72	57.813	0.001	7312.789
162.155	21.012	7023.52	58.106	2651.798	5907.931	220.077	0	9773.232
1208.581	0.3	886.675	9.761	855.159	405.859	0	408.459	55.668
1551.244	1.731	1064.785	16.072	1127.322	415.13	0	232.871	255.239
1622.503	1.731	1785.881	14.718	1203.07	515.824	0	87.774	577.031
1305.72	1.581	2979.112	7.569	1285.545	443.409	0	45.109	1070.444
998.938	0	4738.963	0.552	1545.23	300.53	0	18.924	1627.025
1003.563	0	6410.777	0.552	1602.527	243.48	0	10.704	2537.575
1171.917	0	8364.108	0.33	1679.026	408.626	0	10.285	3798.951
1221.924	0	10508.69	0.198	1744.525	738.856	0	0.645	5229.015
932.452	0	11566.39	0.198	1808.327	1441.858	0	0.001	6584.746
613.012	0	12313.31	0.198	1880.185	2236.559	0	0.001	7574.665
180.631	3.6	12352.25	0.118	2461.538	3639.268	35.062	0	7932.377
1208.573	0.3	886.682	9.761	855.159	405.859	0	408.459	55.668
1551.261	1.731	1065.357	16.072	1127.322	415.13	0	232.871	255.239
1633.631	1.731	1776.817	14.718	1219.093	510.503	1.397	87.775	539.355
1400.377	1.581	2938.788	7.348	1299.642	437.005	1.397	45.109	930.896
1246.33	0	4651.492	0	1449.456	280.877	1.397	18.924	1417.627
1401.864	0	6273.41	0	1496.386	164.578	1.397	10.704	2120.488
1793.776	0	8174.206	0	1559.967	216.564	1.397	10.285	3132.977
2188.913	0	10345.67	0	1660.99	379.041	1.397	0.645	4360.887
2618.646	0	11573.9	0	1771.369	670.335	0	0.001	5090.801
2695.971	0	12595.77	0	1830.528	1171.696	0	0.001	6253.277
2397.212	0	14291.69	0	1847.502	1765.228	17.531	0	7932.747
1336.707		604.4403	8.7966	826.382	446.4509		188.9644	35.3325
1558.797		661.1185	9.1906	947.0204	457.5221		213.0637	43.2872
1906.579		786.1355	10.8795	1217.501	573.113		263.429	106.4602
1866.045		897.294	12.5576	1499.603	853.5622		282.1999	434.5027
1086.447		867.5611	14.4541	2028.14	971.7501		327.0354	1107.792
1120.694		819.178	16.071	2157.197	827.6001		312.2426	1674.147
1293.82		802.2418	17.4926	2234.432	662.012		293.2141	2486.241
1045.381		731.62	18.8817	2443.697	633.5754		266.1866	3793.876
853.6205		659.7239	20.2102	2520.373	635.6717		245.1536	5281.18
684.5843		551.9451	21.5337	2520.373	626.3032		211.284	7135.913
542.5672		456.8641	22.9643	2520.373	602.2237		176.7628	9049.08
1336.707		604.4403	8.7966	826.382	446.4509		188.9644	35.3325

1558.797	661.1185	9.1906	947.0204	457.5221	213.0637	43.2872
1906.579	786.1355	10.8795	1217.501	573.113	263.429	106.4602
2133.929	854.0991	12.351	1498.876	851.9775	284.6063	311.8137
1655.461	879.0911	13.9336	1886.333	951.9803	335.1781	657.2819
1431.409	772.7874	15.5165	2097.747	884.3293	294.7325	1054.178
1398.621	666.0965	16.928	2243.608	796.7804	242.9729	1730
1424.974	675.7736	18.3115	2349.351	690.3162	245.9421	2341.542
1461.077	671.9053	19.6445	2424.754	627.5396	248.9704	3163.73
1415.127	651.6144	20.9754	2485.822	592.1114	248.8693	4336.894
1238.569	606.2031	22.4136	2520.373	598.9519	241.2031	5902.378
1336.707	604.4403	8.7966	826.382	446.4509	188.9644	35.3325
1558.797	661.1185	9.1906	947.0204	457.5221	213.0637	43.2872
1906.579	786.1355	10.8795	1217.501	573.113	263.429	106.4602
2162.3	850.3594	12.297	1498.826	851.8702	284.4476	304.5432
2068.143	880.905	13.6695	1772.887	900.4445	329.1332	563.8515
2029.085	853.2133	15.1108	1979.838	761.259	317.9447	821.7309
2133.272	783.5704	16.4944	2037.209	596.7124	281.2418	1127.665
1867.118	695.7149	17.8686	2184.176	527.3379	257.9778	1516.401
1854.448	612.0258	19.2029	2282.791	479.7949	234.1682	2060.77
2093.876	571.7496	20.5408	2334.624	411.532	225.8197	2656.928
2332.247	539.2225	21.9881	2354.653	360.799	215.9976	3387.528
1336.707	604.4403	8.7966	826.382	446.4509	188.9644	35.3325
1571	661.892	9.194	937.6342	449.3162	213.0396	43.4013
2110.059	783.6254	10.9682	1159.794	524.5556	263.8251	57.1599
2791.207	940.2569	12.7537	1316.08	592.5745	312.7029	75.2413
3496.536	1052.656	14.5341	1528.463	575.1862	357.2171	95.8726
4309.221	1165.433	16.1714	1859.332	494.9324	375.3293	114.2928
5048.089	1188.251	17.6472	2076.555	409.7721	365.6244	153.5991
5868.657	1147.202	19.0954	2159.64	342.2928	368.849	200.2114
6715.017	1096.278	20.5016	2237.118	283.2221	368.2831	269.4603
7610.444	1049.907	21.9155	2283.161	236.0092	381.2876	349.4753
8586.262	1005.416	23.4492	2296.368	206.137	375.2147	450.7418
1225.958	841.2101	9.716098	349.6053	1085.217	0	
1693.754	1140.513	67.0341	510.8682	360.6318	0	
1228.808	1243.012	166.622	1530.018	253.1453	0	
1073.495	1254.237	204.1142	2413.031	129.1626	0	
1071.386	1216.835	223.4281	3153.946	68.90377	0	
931.6911	1224.682	231.3622	3905.114	49.13613	0	
628.7336	1106.922	233.9821	4587.919	49.56565	0	
233.7913	801.3357	231.6631	5183.68	67.5284	0	
50.59647	458.0889	230.0954	5109.573	99.44499	0	
8.568845	148.5998	180.6275	4893.532	63.78672	0	
1225.958	841.2101	9.716106	349.6053	1085.217	0	
1693.754	1140.513	67.0341	510.8682	360.6322	0	
1716.053	1293.324	139.5919	1008.812	305.8904	0	

1345.413	1369.899	182.9874	1846.324	202.3471	0
1006.978	1318.441	207.8897	2701.807	121.6	0
920.5796	1135.353	220.7376	3367.095	77.61129	0
804.8737	1023.967	222.8477	4024.203	49.01813	0
633.9834	937.3923	217.0962	4541.143	44.37575	0
302.3548	720.81	210.888	4839.151	53.88509	0
74.31952	442.4846	199.5887	4794.77	77.12468	0
1225.958	841.2101	9.716106	349.6053	1085.217	0
1693.754	1140.513	67.0341	510.8682	360.6322	0
1846.253	1331.803	128.3021	853.4231	328.418	0
1737.86	1426.401	165.1665	1432.186	230.208	0
1325.98	1432.084	190.7936	2202.566	155.2775	0
934.0023	1214.835	210.5004	2947.221	125.6095	0
782.0435	994.6936	217.2496	3598.212	73.38565	0
689.3045	900.2817	198.5876	3875.422	49.57959	0
637.6053	806.0891	181.7046	4024.789	55.17809	0
532.3713	693.9291	171.8699	4050.719	45.52628	0
1225.958	841.2101	9.716106	349.6053	1085.217	0
1693.754	1140.513	67.0341	510.8682	360.6322	0
2014.376	1395.452	115.6949	727.4788	369.4773	0
2139.452	1536.954	141.358	1042.492	272.6893	0
2160.038	1612.299	150.9597	1360.336	199.7782	0
2150.953	1416.25	157.194	1657.732	208.2219	0
2102.007	1218	161.1226	1974.2	176.1341	0
1592.537	1102.254	171.7487	2391.867	173.2052	0
1035.827	978.3102	174.6699	2804.311	170.1273	0
501.7329	848.5339	170.2217	3150.743	129.49	0
1031.966	631.8461	8.304925	351.0846	1239.128	
1225.958	841.2101	9.716106	349.6053	1085.217	
1748.912	1187.257	64.68386	481.8749	432.9278	
2085.85	1435.85	112.3128	698.3523	397.5347	
2239.666	1598.721	136.5254	985.0269	307.3984	
2297.31	1696.712	144.5328	1261.837	232.3134	
2326.558	1527.514	148.3682	1508.224	250.9439	
2349.912	1332.252	147.6353	1750.521	222.5091	
1962.312	1251.47	151.7688	2031.551	234.5549	
1681.387	1175.393	149.1296	2191.384	247.3909	
1453.393	1166.226	141.6507	2238.914	235.0923	
1134	0	925.2	7.727	702.4	400.9
1299	0.53	1147	11.55	743.3	403.7
1297	4.427	2241	14.31	702.1	481.9
650.4	66.08	2761	33.26	890.5	830.6
134.4	684.5	1752	42.76	2105	1627
0.5999	3009	1165	43.19	3539	2295
0.2419	6551	730.5	42.26	4102	2659

0.0664	9700	383.8	40.25	4326	2854
0.0826	12420	150.4	39.48	4515	2809
0.089	15000	84.77	39.3	4683	2662
0.0777	17940	45.36	39.46	4798	2485
1134	0	925.2	7.727	702.4	400.9
1299	0.53	1147	11.55	743.3	403.7
1297	4.427	2241	14.31	702.1	481.9
705.5	12.25	4062	28.5	750.4	681.5
187.1	116.1	4742	38.83	1277	1159
2.116	737	4367	42.28	2403	1894
1.084	2674	3793	43.41	3483	2501
0.601	5964	2841	42.9	4084	2890
0.3086	10050	1375	42.32	4288	3018
0.1041	13850	581.3	41.11	4390	2799
0.0772	16980	302.8	40.33	4475	2500
1134	0	925.2	7.727	702.4	400.9
1299	0.53	1147	11.55	743.3	403.7
1297	4.427	2241	14.31	702.1	481.9
827.5	5.07	4448	27.05	705.6	615.4
329	24.87	6057	36.38	987.6	881.8
103.4	208.9	6566	40.21	1762	1356
41.39	1074	6481	42.27	2745	1920
32.71	3383	5398	43.41	3585	2464
19.61	7306	3399	43.41	4100	2888
7.433	11640	1470	42.89	4277	2935
6.648	15280	826.4	43.41	4354	2645
1134	0	925.2	7.727	702.4	400.9
1299	0.53	1147	11.55	743.3	403.7
1297	4.427	2241	14.31	702.1	481.9
882.8	4.449	4444	26.59	696.8	606.5
484.5	9.686	6128	35.54	929.2	848.6
356.9	79.89	6801	39.47	1598	1307
285.6	485.9	6545	41.62	2448	1880
275.1	1782	5876	43.07	3164	2341
274	4345	4733	43.41	3744	2654
294.4	7587	3308	42.93	4080	2703
366.9	10330	2351	43.41	4209	2492
1134	0	925.2	7.727	702.4	400.9
1299	0.53	1147	11.55	743.3	403.7
1297	4.427	2241	14.31	702.1	481.9
1255	4.25	4364	24.53	663	545.8
1188	4.001	6536	32.5	742.3	632.8
1089	13.13	8096	37.9	1132	880.7
981.1	103	8132	40.75	1866	1396
787.7	477.8	6937	42.44	2537	2178
638.7	1517	5343	43.41	3132	2973
640.7	3668	3864	43.16	3741	3259

638.1	6746	2478	43.41	4214	3012
1134	0	925.2	7.727	702.4	400.9
1299	0.53	1147	11.55	743.3	403.7
1577	4.427	2027	12.73	688.8	480.8
2231	4.25	3415	17.68	610.6	487.5
3262	3.219	5041	23.12	564.3	425.6
4381	1.778	6260	31.25	638.7	348.6
5449	7.336	6718	35.64	956.4	246.4
6210	46.87	6798	38.54	1540	203.6
6476	223.7	6654	40.95	2193	383.1
6202	788.4	6056	42.26	2640	763.2
5519	2056	4878	43.41	3011	1304

Solar capacity	Solar PV capacity	Wind capacity	Black carbon emissions	Methane emissions	Fossil methane emissions	Land methane emissions	Carbon monoxide emissions	CO2 emissions
4.902305	4.493854	58.71616	10166850	3.18E+08		1.54E+08	NaN	33166074220
40.07435	38.81835	196.3347	10420980	3.48E+08		1.64E+08	NaN	35488828780
287.0316	278.7625	489.8592	7281273	3E+08		1.53E+08	NaN	33208799480
404.7742	386.177	527.2326	3990174	2.15E+08		1.23E+08	NaN	17967968260
2934.135	2356.771	1489.58	3308903	1.79E+08		1.06E+08	NaN	6413946208
4996.537	3018.016	2887.284	2538134	1.53E+08		86351827	NaN	968036255
6170.391	2479.491	2990.311	2308984	1.44E+08		82002647	NaN	-1649998545
6299.851	1121.271	2299.043	2174113	1.36E+08		78378320	NaN	-4136923829
7206.669	1247.092	2385.674	2040057	1.26E+08		74407122	NaN	-7370205445
7876.061	1519.415	2820.787	1907362	1.17E+08		70342212	NaN	-10567707520
7878.032	1674.331	2567.231	1797451	1.1E+08		66408749	NaN	-14340424640
4.902305	4.493854	58.71616	10166850	3.18E+08		1.54E+08	NaN	33166074220
40.07435	38.81835	196.3347	10420980	3.48E+08		1.64E+08	NaN	35488821620
254.8332	248.4439	464.8689	7713113	3.15E+08		1.53E+08	NaN	38389781580
659.4355	586.6677	834.7365	4706756	2.57E+08		1.33E+08	NaN	33930925130
2162.961	1664.803	1400.709	3825954	2.2E+08		1.11E+08	NaN	25904736820
4640.146	2825.75	2149.935	3227433	1.9E+08		92485721	NaN	17732934570
6474.691	2826.229	2716.169	2945252	1.75E+08		87122877	NaN	10565807940
7558.562	2124.222	2891.127	2767615	1.57E+08		83303713	NaN	4785242147
8098.997	1710.022	2819.348	2417529	1.35E+08		76434132	NaN	-2921840088
8053.079	1702.233	2447.211	2236856	1.28E+08		72927185	NaN	-8098321208
10154.25	2548.979	2564.552	1934944	1.2E+08		68847568	NaN	-8347350180
4.902305	4.493854	58.71616	10166850	3.18E+08		1.54E+08	NaN	33166074220
40.07435	38.81835	196.3347	10420980	3.48E+08		1.64E+08	NaN	35488818040
254.2848	248.4939	462.5553	7821450	3.54E+08		1.6E+08	NaN	39638793620
566.0787	534.8782	767.1098	4998291	3.09E+08		1.41E+08	NaN	39351400720
1674.526	1476.144	1396.501	4199383	2.69E+08		1.3E+08	NaN	37443119140
4245.226	3405.635	2311.604	3495168	2.39E+08		1.15E+08	NaN	32947266600
6727.268	4271.827	2654.546	3211494	2.15E+08		1.06E+08	NaN	27955583340
8742.543	3960.322	3058.818	2924976	1.79E+08		88706014	NaN	19813280930
9592.789	3083.137	3392.763	2534620	1.55E+08		80541286	NaN	9123370281
9160.915	2518.868	3189.764	2234435	1.35E+08		75176611	NaN	-2275437907
9642.938	2792.133	2956.867	2142955	1.31E+08		74410852	NaN	-6615458456
4.902305	4.493854	58.71616	10166850	3.18E+08		1.54E+08	NaN	33166074220
40.07435	38.81835	196.3347	10420980	3.48E+08		1.64E+08	NaN	35488818040
253.9978	248.2736	462.0992	7894477	3.58E+08		1.62E+08	NaN	39860114910
543.5984	517.9706	741.6077	5238015	3.31E+08		1.44E+08	NaN	40958095380
1461.163	1336.332	1315.353	4443136	3.12E+08		1.36E+08	NaN	41498599290
3629.455	3237.387	2194.654	3655778	2.98E+08		1.25E+08	NaN	40020968430

5968.284	4887.702	2579.446	3274412	2.66E+08	1.19E+08	NaN	37734730150
8790.074	5745.356	2768.666	2991351	2.29E+08	1.13E+08	NaN	32323002280
10580.37	5265.504	3220.98	2611052	1.91E+08	1.03E+08	NaN	24455647950
10931.2	4539.917	3538.122	2274801	1.62E+08	89280899	NaN	17307671060
10630.27	3941.984	3403.578	1954180	1.4E+08	77464208	NaN	11079046390
4.902305	4.493854	58.71616	10166850	3.18E+08	1.54E+08	NaN	33166074220
40.07435	38.81835	196.3347	10420980	3.48E+08	1.64E+08	NaN	35488818040
253.8592	248.1587	461.8882	7955021	3.66E+08	1.64E+08	NaN	40069003910
537.767	513.4432	733.804	5752160	3.81E+08	1.63E+08	NaN	42653234050
1412.255	1300.742	1295.155	4851265	3.9E+08	1.58E+08	NaN	43778496100
3444.046	3115.606	2149.746	3782655	3.8E+08	1.48E+08	NaN	42454757820
5616.793	4843.553	2502.719	3271831	3.62E+08	1.41E+08	NaN	41601928390
8186.35	6173.347	2665.757	3005288	3.39E+08	1.38E+08	NaN	39217531580
10594.35	6612.197	2988.763	2631899	3.05E+08	1.36E+08	NaN	33392293950
11387.18	6077.83	3082.226	2260235	2.73E+08	1.32E+08	NaN	28618413900
10981.92	5335.141	3019.136	1972020	2.46E+08	1.29E+08	NaN	24612913580
3.7	3.4	55.351	6897883	3.34E+08	1.47E+08	NaN	37767241830
39.781	38.05	254.922	7033091	3.26E+08	1.5E+08	NaN	40313502030
259.191	257.46	653.669	5953591	3.3E+08	1.52E+08	NaN	40931321740
1239.157	1226.951	2182.785	5042782	2.68E+08	1.51E+08	NaN	23633128530
2544.946	2488.794	4718.195	4466717	2.2E+08	1.32E+08	NaN	11524129400
4807.605	4653.824	6720.197	3953877	1.92E+08	1.16E+08	NaN	3778922018
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10635.17	9976.307	11241.47	2978596	1.47E+08	92033232	NaN	-6540368386
12784.66	11665.13	14350.26	2456218	1.27E+08	83271741	NaN	-10608864180
15765.84	14005.63	17454.23	2022746	1.13E+08	75616620	NaN	-12410880580
20556.68	17850.64	21263.45	1882179	1.03E+08	68898560	NaN	-13048889880
3.7	3.4	55.668	6897921	3.34E+08	1.47E+08	NaN	37770820260
39.781	38.05	255.239	7032949	3.27E+08	1.5E+08	NaN	40294322570
259.181	257.45	652.475	5962082	3.31E+08	1.51E+08	NaN	40656969190
360.494	358.913	1556.941	5395076	3.08E+08	1.6E+08	NaN	34541602380
823.885	823.885	2516.159	4814379	2.7E+08	1.53E+08	NaN	26305611870
1959.471	1948.031	3682.721	4197154	2.44E+08	1.42E+08	NaN	16330601410
3538.011	3488.125	5074.169	3649116	2.26E+08	1.29E+08	NaN	9247853483
6197.911	6057.543	6890.792	3129527	2.18E+08	1.18E+08	NaN	2010280498
9116.889	8807.56	10286.83	2652950	2E+08	1.08E+08	NaN	-4045766822
13017.6	12412.79	15150.51	2214105	1.76E+08	98074308	NaN	-6495753010
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3.7	3.4	55.668	6897921	3.34E+08	1.47E+08	NaN	37770833690
39.781	38.05	255.239	7032939	3.27E+08	1.5E+08	NaN	40294283120
259.181	257.45	648.413	5954571	3.33E+08	1.54E+08	NaN	41685860990
290.108	288.527	1210.556	5551665	3.37E+08	1.66E+08	NaN	42031556660
507.87	507.87	2127.393	5092204	3.02E+08	1.62E+08	NaN	38219667350
1138.34	1138.34	3282.19	4528868	2.78E+08	1.56E+08	NaN	32611938560
2433.64	2433.64	4538.994	3926427	2.57E+08	1.47E+08	NaN	24302660540
3951.654	3947.478	5643.336	3280636	2.49E+08	1.38E+08	NaN	15423403940
5660.827	5630.586	7046.438	2686918	2.43E+08	1.27E+08	NaN	7974427459

8966.094	8866.533	10342.8	2356392	2.31E+08	1.17E+08	NaN	1860016865
12294.81	12060.32	15088.78	2305570	2.12E+08	1.06E+08	NaN	-1418092488
3.7	3.4	55.668	6897921	3.34E+08	1.47E+08	NaN	37770827990
39.781	38.05	255.239	7032940	3.27E+08	1.5E+08	NaN	40294293820
259.181	257.45	586.564	5950466	3.36E+08	1.55E+08	NaN	42284928730
267.815	266.234	1197.518	5587177	3.47E+08	1.67E+08	NaN	44385654470
365.293	365.293	1937.532	5162646	3.32E+08	1.71E+08	NaN	44491570780
670.059	670.059	2900.356	4620340	3.12E+08	1.67E+08	NaN	42832156140
1317.231	1317.231	4336.712	4176487	2.91E+08	1.6E+08	NaN	39042389740
2692.117	2692.117	5505.533	3639191	2.81E+08	1.52E+08	NaN	34193217950
4044.339	4044.339	6345.111	3016475	2.69E+08	1.44E+08	NaN	25823818090
6636.43	6630.519	7370.602	2425261	2.62E+08	1.34E+08	NaN	15468528590
8900.084	8879.072	9993.309	2190230	2.57E+08	1.23E+08	NaN	9115046702
3.7	3.4	55.668	6897921	3.34E+08	1.47E+08	NaN	37770773340
39.781	38.05	255.239	7032940	3.27E+08	1.5E+08	NaN	40294276410
259.181	257.45	577.031	5955364	3.39E+08	1.57E+08	NaN	42392228060
260.893	259.312	1070.444	5639539	3.62E+08	1.68E+08	NaN	46125215530
274.78	274.78	1627.025	5243723	3.73E+08	1.76E+08	NaN	49544828530
311.474	311.474	2537.575	4745865	3.68E+08	1.8E+08	NaN	52585738920
666.343	666.343	3798.951	4324438	3.54E+08	1.78E+08	NaN	54663549370
1471.99	1471.99	5229.015	3780013	3.46E+08	1.74E+08	NaN	55537153420
2648.202	2648.202	6584.746	3287629	3.27E+08	1.69E+08	NaN	55974066830
4307.712	4307.712	7574.665	2840070	3.15E+08	1.61E+08	NaN	56218816630
5843.083	5839.483	7967.439	2592205	2.9E+08	1.53E+08	NaN	55426330740
3.7	3.4	55.668	6897915	3.34E+08	1.47E+08	NaN	37768994360
39.781	38.05	255.239	7032933	3.27E+08	1.5E+08	NaN	40294638280
259.181	257.45	540.752	5989514	3.45E+08	1.58E+08	NaN	42262425250
257.331	255.75	932.293	5669987	3.73E+08	1.69E+08	NaN	46727550650
238.229	238.229	1419.024	5271352	3.93E+08	1.77E+08	NaN	51606451500
159.66	159.66	2121.885	4853472	4.11E+08	1.83E+08	NaN	56651629190
382.054	382.054	3134.374	4443642	4.26E+08	1.87E+08	NaN	61402269010
899.171	899.171	4362.284	3947394	4.33E+08	1.88E+08	NaN	65996979000
1335.941	1335.941	5090.801	3434581	4.36E+08	1.87E+08	NaN	74133629280
2096.954	2096.954	6253.277	2952570	4.34E+08	1.87E+08	NaN	81028376880
3374.932	3374.932	7950.278	2717675	4.22E+08	1.86E+08	NaN	85684204390
1.2895	1.2895	35.3325	8334800	3.5E+08	1.7E+08	NaN	34373934500
11.877	11.877	43.2872	7903800	3.76E+08	1.85E+08	NaN	39398615600
26.7852	26.7852	106.4602	8340500	4.24E+08	2.15E+08	NaN	46637736200
134.9159	134.9159	434.5027	8348000	4.58E+08	2.42E+08	NaN	48292181400
590.6526	590.6526	1107.792	6578600	3.43E+08	2.09E+08	NaN	32552846300
1230.742	1230.742	1674.147	6182300	2.94E+08	2E+08	NaN	22930895200
1836.412	1836.412	2486.241	5798800	3.01E+08	2.1E+08	NaN	16754039300
2650.958	2650.958	3793.876	5327600	2.96E+08	2.14E+08	NaN	9494704600
3895.256	3895.256	5281.18	4959700	2.94E+08	2.18E+08	NaN	3925184500
5353.665	5353.665	7135.913	4670700	2.93E+08	2.23E+08	NaN	-713415000
7078.745	7078.745	9049.08	4462100	2.94E+08	2.27E+08	NaN	-3861942700
1.2895	1.2895	35.3325	8334800	3.5E+08	1.7E+08	NaN	34373934500

11.877	11.877	43.2872	7903800	3.76E+08	1.85E+08	NaN	39398615600	
26.7852	26.7852	106.4602	8340500	4.24E+08	2.15E+08	NaN	46637736200	
102.2534	102.2534	311.8137	8385700	4.68E+08	2.44E+08	NaN	50589140800	
335.3812	335.3812	657.2819	7293100	3.73E+08	2.26E+08	NaN	43026225700	
746.8559	746.8559	1054.178	6842900	3.47E+08	2.22E+08	NaN	36561864000	
1276.55	1276.55	1730	6157400	3.37E+08	2.26E+08	NaN	25470368300	
1694.822	1694.822	2341.542	5824900	3.45E+08	2.36E+08	NaN	19713865200	
2210.791	2210.791	3163.73	5447000	3.51E+08	2.46E+08	NaN	15958927700	
3026.237	3026.237	4336.894	5073700	3.52E+08	2.53E+08	NaN	11400028500	
4249.112	4249.112	5902.378	4735100	3.47E+08	2.55E+08	NaN	6401836300	
1.2895	1.2895	35.3325	8334800	3.5E+08	1.7E+08	NaN	34373934500	
11.877	11.877	43.2872	7903800	3.76E+08	1.85E+08	NaN	39398615600	
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100.3114	100.3114	304.5432	8388600	4.7E+08	2.45E+08	NaN	50805267700	
282.7516	282.7516	563.8515	7713300	4.08E+08	2.39E+08	NaN	48074469800	
573.4055	573.4055	821.7309	7336600	3.93E+08	2.4E+08	NaN	46888112200	
822.4284	822.4284	1127.665	7000600	4.2E+08	2.6E+08	NaN	48048435800	
1105.647	1105.647	1516.401	6500800	4.24E+08	2.7E+08	NaN	43526677200	
1496.907	1496.907	2060.77	6002100	4.29E+08	2.81E+08	NaN	37554195400	
1897.121	1897.121	2656.928	5606800	4.43E+08	2.93E+08	NaN	33712190900	
2349.263	2349.263	3387.528	5250600	4.53E+08	3.04E+08	NaN	31248202100	
1.2895	1.2895	35.3325	8334800	3.5E+08	1.7E+08	NaN	34373934500	
11.7908	11.7908	43.4013	7907600	3.77E+08	1.85E+08	NaN	39560752300	
19.4	19.4	57.1599	8366100	4.36E+08	2.19E+08	NaN	48502706900	
33.1709	33.1709	75.2413	8392600	4.9E+08	2.49E+08	NaN	55000886500	
53.8618	53.8618	95.8726	8478400	5.34E+08	2.75E+08	NaN	59877305400	
81.5896	81.5896	114.2928	8160500	5.75E+08	2.99E+08	NaN	64001363000	
108.3326	108.3326	153.5991	7636100	6.15E+08	3.22E+08	NaN	67962295200	
139.5087	139.5087	200.2114	7169500	6.55E+08	3.46E+08	NaN	71792665700	
186.9195	186.9195	269.4603	6686300	6.95E+08	3.69E+08	NaN	75571458400	
241.6192	241.6192	349.4753	6254300	7.34E+08	3.91E+08	NaN	80137183400	
309.9962	309.9962	450.7418	5842600	7.74E+08	4.13E+08	NaN	85214965500	
1.8E+08								
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209.0308		404.5147	7466236	3.94E+08	1.98E+08	1.96E+08	NaN	40048785360
587.7284		1277.995	6513433	3.45E+08	1.39E+08	2.05E+08	NaN	23821810490
1192.871		1968.717	6340488	3.58E+08	1.36E+08	2.22E+08	NaN	16324223230
2087.153		2398.587	6135944	3.57E+08	1.2E+08	2.38E+08	NaN	11881383240
3205.443		2401.154	5551899	3.57E+08	1.09E+08	2.48E+08	NaN	6666028153
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6248.721		3414.235	3027330	3.31E+08	69611978	2.61E+08	NaN	-19091439440
6814.553		3666.341	2396296	3.22E+08	60888904	2.6E+08	NaN	-27544504870
1.8E+08								
18.78684		92.8781	7718361	3.68E+08	1.93E+08	1.75E+08	NaN	35775762490
209.0309		404.5145	7466235	3.94E+08	1.98E+08	1.96E+08	NaN	40048796730
501.24		901.5399	6802658	3.69E+08	1.58E+08	2.11E+08	NaN	35021114670

1043.843	1561.587	6539055	3.84E+08	1.55E+08	2.29E+08	NaN	28099447300	
1872.604	2061.328	6111320	3.81E+08	1.36E+08	2.45E+08	NaN	19939745670	
2947.763	2305.174	5562365	3.8E+08	1.23E+08	2.57E+08	NaN	14798745000	
4064.483	2419.84	5193894	3.75E+08	1.08E+08	2.66E+08	NaN	10246934590	
4940.425	2528.199	4650051	3.66E+08	93701918	2.72E+08	NaN	2773520564	
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6775.543	3364.205	2930349	3.45E+08	68415249	2.76E+08	NaN	-15962104440	
			1.8E+08					
18.78684	92.8781	7718361	3.68E+08	1.93E+08	1.75E+08	NaN	35775762450	
209.0309	404.5145	7466235	3.94E+08	1.98E+08	1.96E+08	NaN	40048795810	
463.2488	781.4397	7031678	3.84E+08	1.7E+08	2.14E+08	NaN	39451086240	
944.7735	1274.394	6755184	4.04E+08	1.7E+08	2.34E+08	NaN	36566084270	
1705.505	1721.088	6270053	4.03E+08	1.51E+08	2.52E+08	NaN	29034578190	
2748.928	2125.479	5644192	3.98E+08	1.35E+08	2.63E+08	NaN	21480445160	
3853.717	2358.573	5161175	3.92E+08	1.18E+08	2.74E+08	NaN	15715357360	
4476.949	2173.831	4063033	4.01E+08	1.13E+08	2.88E+08	NaN	10931517500	
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5657.641	2317.973	3361681	4.05E+08	95610164	3.08E+08	NaN	7694019169	
			1.8E+08					
18.78684	92.8781	7718361	3.68E+08	1.93E+08	1.75E+08	NaN	35775762450	
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2125.656	1243.843	6310183	4.79E+08	1.91E+08	2.88E+08	NaN	47612523330	
2923.487	1357.16	5629815	4.75E+08	1.74E+08	3.01E+08	NaN	44591015670	
3674.966	1650.892	4864903	4.63E+08	1.52E+08	3.11E+08	NaN	36805763550	
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2.470956	29.67401	7181345	3.43E+08	1.8E+08	1.63E+08	NaN	31887169360	
18.78684	92.8781	7718361	3.68E+08	1.93E+08	1.75E+08	NaN	35775774720	
194.7604	365.9908	7717644	4.15E+08	2.17E+08	1.98E+08	NaN	41636027050	
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1997.322	1128.073	6561339	5.63E+08	2.68E+08	2.95E+08	NaN	56953976660	
2705.515	1179.41	5903478	5.75E+08	2.62E+08	3.13E+08	NaN	55898208470	
3307.738	1357.156	5161018	5.7E+08	2.4E+08	3.3E+08	NaN	51172922990	
3810.335	1502.615	4485016	5.68E+08	2.24E+08	3.44E+08	NaN	47532718760	
4281.432	1648.492	3826581	5.62E+08	2.05E+08	3.57E+08	NaN	44784721730	
1.053	1.053	39.69	6741900	3.34E+08	1.06E+08	1.57E+08	NaN	35280000000
39.35	38.82	180.4	6625300	3.71E+08	1.22E+08	1.71E+08	NaN	36370000000
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1.053	1.053	39.69	6725500	3.34E+08	1.06E+08	1.57E+08	NaN	35229942500
39.35	38.82	180.4	6710000	3.71E+08	1.22E+08	1.72E+08	NaN	36335005000
269.5	265.1	514.7	6409600	3.91E+08	1.24E+08	2.04E+08	NaN	39561252300
285.8	273.6	911.8	5502500	3.39E+08	86520000	2.07E+08	NaN	43164648300
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51560	34580	23740	2191700	1.39E+08	1274000	1.14E+08	NaN	-18976585200
1.053	1.053	39.69	6725500	3.34E+08	1.06E+08	1.57E+08	NaN	35229942500
39.35	38.82	180.4	6710000	3.71E+08	1.22E+08	1.72E+08	NaN	36335005000
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1.053	1.053	39.69	6725500	3.34E+08	1.06E+08	1.57E+08	NaN	35229942500
39.35	38.82	180.4	6709000	3.71E+08	1.22E+08	1.72E+08	NaN	36335005000
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907.2	804.2	2643	3756600	3.66E+08	95480000	2.3E+08	NaN	58939778700
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8851	7334	7843	3083300	2.77E+08	55720000	1.94E+08	NaN	50540137300
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23160	16410	14150	2543100	2.02E+08	34390000	1.44E+08	NaN	40968865200
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39.35	38.82	180.4	6624300	3.71E+08	1.22E+08	1.71E+08	NaN	36371124600
269.5	265.1	484.5	6682800	4.08E+08	1.21E+08	2.19E+08	NaN	44610389300
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183.3	180.1	538.5	5474300	5.7E+08	1.86E+08	3.08E+08	NaN	69861617000
22.5	20.72	936.7	4490500	6.31E+08	2.1E+08	3.32E+08	NaN	84436466100
43.59	36.26	1736	4027200	6.45E+08	2.28E+08	3.36E+08	NaN	1.01302E+11
352.5	305.6	2845	3649000	6.46E+08	2.37E+08	3.31E+08	NaN	1.175E+11
1673	1449	4396	3356300	6.21E+08	2.3E+08	3.15E+08	NaN	1.29499E+11
5083	4295	6864	3016200	5.83E+08	2.24E+08	2.84E+08	NaN	1.30398E+11
10410	8353	9328	2683600	5.4E+08	2.05E+08	2.45E+08	NaN	1.26098E+11

CO2 emissions (BECCS)	CO2 emissions (CCS)	Fossil CO2 emissions	Land CO2 emissions	F-gas emissions	Kyoto gas emisisions	Nitrous oxide emissions	Land nitrous oxide emissions
0	0	29394248380	3771829776	6.73E+08	4.45E+10	9156453	6874411
0	0	31981488160	3507338835	8.78E+08	4.8E+10	9831880	7486986
48300128.47	181468957.1	30554137570	2654661229	1.59E+09	4.51E+10	9276022	7310205
1001573983	2510513471	17442727580	525239686	9.6E+08	2.66E+10	7595500	7017176
3547881355	8466587109	5342759350	1071187443	2.01E+08	1.34E+10	7678852	7237962
4244053177	10766619420	1609828849	-641792978	2.01E+08	7.26E+09	7570986	7181883
5180821375	12368708430	-316956993	-1.333E+09	1.86E+08	4.41E+09	7602241	7225174
6748824947	14600111380	-2441226653	-1.696E+09	1.98E+08	1.77E+09	7763508	7375831
9072973656	15589320970	-5286835066	-2.083E+09	2.04E+08	-1.6E+09	7995745	7581611
11448356010	16076111720	-8181154877	-2.387E+09	2.05E+08	-5E+09	8115737	7678941
14863338630	17904460390	-1.1956E+10	-2.384E+09	1.97E+08	-8.9E+09	8304321	7806639
0	0	29394248380	3771829776	6.73E+08	4.45E+10	9156453	6874411
0	0	31981486300	3507338835	8.78E+08	4.8E+10	9831880	7486986
0	0.000988881	35747980190	2641799594	1.59E+09	5.07E+10	9423506	7297469
18086619.37	524065015	33774290820	156634828	1.23E+09	4.41E+10	8282467	7069792
579823728.1	3298166839	26247477800	-342740571	3.01E+08	3.4E+10	7744856	6973778
1571773140	5549699388	19333121840	-1.6E+09	2.01E+08	2.5E+10	7593677	6965591
3406105493	8620201536	13000064510	-2.434E+09	1.87E+08	1.74E+10	7593437	6997674
5531164173	11074010720	7288206169	-2.503E+09	2E+08	1.12E+10	7705696	7176346
9437241775	14819451400	-474654898	-2.447E+09	2.05E+08	3.06E+09	8025622	7523306
12869307720	17942193080	-6002102559	-2.096E+09	2.05E+08	-2.1E+09	8541920	7969961
11905838950	16210222530	-5455439498	-2.892E+09	1.97E+08	-2.7E+09	8354563	7830376
0	0	29394248380	3771829776	6.73E+08	4.45E+10	9156453	6874411
0	0	31981483730	3507338835	8.78E+08	4.8E+10	9831880	7486986
2.70E-17	2.75811E-06	36882478030	2756302610	1.73E+09	5.32E+10	10031736	7592137
2.68E-17	846167.703	38624051270	727344026	2.15E+09	5.21E+10	9583044	7219632
40209.217	18249570.17	37437271410	5857696.14	1.85E+09	4.86E+10	8818760	7102811
1624083.599	180133601.2	34600764420	-1.653E+09	1.58E+09	4.3E+10	8299699	7037538
83991789.47	937278232	30959729340	-3.004E+09	8.2E+08	3.65E+10	7958206	6984294
699327848	2977974101	23490119140	-3.677E+09	3.18E+08	2.69E+10	7679417	7033498
3001087249	6698987919	13161433990	-4.038E+09	2.05E+08	1.55E+10	7689181	7174649
8500910441	12814245630	1222890729	-3.498E+09	2.05E+08	3.75E+09	8224124	7707124
11460774660	15622254410	-3862332290	-2.753E+09	1.98E+08	-5.6E+08	8709586	8122395
0	0	29394248380	3771829776	6.73E+08	4.45E+10	9156453	6874411
0	0	31981483730	3507338835	8.78E+08	4.8E+10	9831880	7486986
3.70E-13	2.53074E-06	36878281680	2981847515	1.73E+09	5.35E+10	10072584	7630968
5632.408	465017.708	39609203090	1348884106	2.34E+09	5.46E+10	9992092	7434233
5609.29	3245045.894	40999569500	499018915	3.12E+09	5.54E+10	9848718	7330992
3645.922	8648049.931	41131823270	-1.111E+09	3.59E+09	5.4E+10	9771553	7261805

0.00026718	26231309.78	39869303650	-2.135E+09	3.21E+09	5.03E+10	9216565	7007165
0	64835342.57	34822086520	-2.499E+09	2.7E+09	4.33E+10	8517984	7017335
107766803.5	549812019.3	27142304760	-2.687E+09	1.55E+09	3.32E+10	7976796	7178367
746724340	1754321235	19869667600	-2.562E+09	9.51E+08	2.46E+10	7795871	7277055
1966141097	3320564857	14046561140	-2.968E+09	9.12E+08	1.78E+10	7658984	7236095
0	0	29394248380	3771829776	6.73E+08	4.45E+10	9156453	6874411
0	0	31981483730	3507338835	8.78E+08	4.8E+10	9831880	7486986
0	0	36892236180	3176769580	1.73E+09	5.4E+10	10193926	7747131
0	0	39680275450	2972975654	2.35E+09	5.77E+10	10514839	7926474
0	0	41860775850	1917707024	3.14E+09	5.98E+10	10616954	7938957
0	0	42668609650	-213854482	3.6E+09	5.87E+10	10498269	7832364
0	0	43038298390	-1.436E+09	3.96E+09	5.77E+10	10268842	7676166
0	0	40936403490	-1.719E+09	4.36E+09	5.51E+10	10159419	7752950
0	0	35332480670	-1.94E+09	4.74E+09	4.87E+10	10014053	7924046
0	0	30633360380	-2.015E+09	4.86E+09	4.32E+10	9825722	8048353
0	0	27049003560	-2.436E+09	4.67E+09	3.82E+10	9418887	7948266
0	0	30872683090	6894558733	5.48E+08	4.9E+10	8286062	6106337
0	0	33151923900	7161578136	7.33E+08	5.18E+10	8748512	6443245
0	0	36454559350	4476762383	1.5E+09	5.35E+10	9564997	6983375
67415333.33	1845829333	22911514290	721614238	8.68E+08	3.41E+10	9770745	7378650
363495000	5694960333	13019793930	-1.496E+09	8.56E+08	2.06E+10	9218903	7068786
1313429333	8602110000	6064363433	-2.285E+09	9.21E+08	1.19E+10	8196763	6467859
3293004000	9090268000	1875603819	-3.386E+09	9.53E+08	5.86E+09	7417859	5790486
7205286000	10568580000	-2972924572	-3.567E+09	9.47E+08	9374058	6556566	5295827
10720284670	12510168000	-6872422068	-3.736E+09	9.31E+08	-4.7E+09	6111998	4822445
11628235670	12918693330	-8159471231	-4.251E+09	9.09E+08	-7E+09	5636218	4384968
12361767000	13606992670	-8886574330	-4.162E+09	9.07E+08	-8E+09	5251328	4007440
0	0	30875871770	6894948483	5.48E+08	4.9E+10	8285953	6106337
0	0	33132878790	7161443786	7.33E+08	5.18E+10	8758093	6443245
0	14798666.67	36219184280	4437784919	1.49E+09	5.33E+10	9580786	6976084
61189333.33	1149261667	31750765980	2790836408	9.87E+08	4.63E+10	10277922	7599065
256457666.7	4564640667	26208463810	97148063.9	1.06E+09	3.72E+10	10349797	7781372
828157000	11005459670	18325215930	-1.995E+09	1.15E+09	2.65E+10	9923819	7693109
2459310333	16585477330	12620939560	-3.373E+09	1.1E+09	1.88E+10	9441261	7314837
5930734333	22888701000	5288097573	-3.278E+09	1.12E+09	1.12E+10	8757517	6910593
8666984333	24607289670	214677135.3	-4.26E+09	1.13E+09	4.39E+09	7835717	6465640
10180327670	23031107000	-2646276598	-3.849E+09	1.13E+09	1.17E+09	7268904	5940648
11366424670	20883863000	-4570578650	-3.787E+09	1.15E+09	-1.3E+09	6671173	5423402
0	0	30875885210	6894948483	5.48E+08	4.9E+10	8285953	6106337
0	0	33132839330	7161443786	7.33E+08	5.18E+10	8758093	6443245
0	6600000	36374401860	5311459130	1.49E+09	5.44E+10	9631906	7026713
20804666.67	238788000	37890790320	4140766338	1.33E+09	5.49E+10	10533281	7726294
118488333.3	1272102333	36303415400	1916251951	1.26E+09	5.03E+10	10912855	8069431
458403000	3753273333	33526900250	-914961693	1.23E+09	4.4E+10	10885182	8196909
1541345667	9559905667	26728912900	-2.426E+09	1.28E+09	3.51E+10	10501365	8068474
4020786000	18223894330	18553511950	-3.13E+09	1.32E+09	2.59E+10	10011508	7846793
6248308000	25325292670	11941196540	-3.967E+09	1.23E+09	1.79E+10	9009501	7539847

7699860667	28697324330	6617872360	-4.758E+09	1.25E+09	1.14E+10	8466669	7058645
9249130000	30033615330	3010926951	-4.429E+09	1.27E+09	7.51E+09	7935093	6488844
0	0	30875879500	6894948483	5.48E+08	4.9E+10	8285953	6106337
0	0	33132850030	7161443786	7.33E+08	5.18E+10	8758092	6443245
0	0	36614540740	5670387997	1.49E+09	5.5E+10	9657447	7049354
6537666.667	78829666.67	39797164350	4588490119	1.54E+09	5.77E+10	10608980	7766986
36586000	415873333.3	41313937900	3177632881	1.43E+09	5.75E+10	11182377	8241589
151033666.7	1329727667	42149946470	682209671	1.27E+09	5.53E+10	11372071	8506016
468629333.3	3384582667	40998072440	-1.956E+09	1.34E+09	5.1E+10	11265046	8555433
1350433333	7474463333	36823849840	-2.631E+09	1.39E+09	4.58E+10	10868119	8450018
3052155333	14496617670	29625244140	-3.801E+09	1.41E+09	3.69E+10	9965779	8241015
4914063000	23273308670	20027979270	-4.559E+09	1.44E+09	2.62E+10	9361891	7885944
6361483333	31789710330	13915123670	-4.8E+09	1.37E+09	1.95E+10	8776604	7415498
0	0	30875824860	6894948483	5.48E+08	4.9E+10	8285953	6106337
0	0	33132832630	7161443786	7.33E+08	5.18E+10	8758093	6443245
0	0	36732975960	5659252105	1.49E+09	5.52E+10	9686537	7077714
0	0	41457853860	4667361668	1.81E+09	6.02E+10	10669539	7791600
0	0	45673434400	3871394132	2.29E+09	6.45E+10	11386542	8365284
0	0	50303836400	2281902526	2.58E+09	6.79E+10	11755891	8783467
0	86969666.67	54122052590	541496776	2.68E+09	6.97E+10	11898688	9022266
0	560681000	56403334390	-866180966	2.23E+09	6.99E+10	11805878	9134691
2156000	1910692667	58649808720	-2.676E+09	1.5E+09	6.9E+10	11383193	9105311
24522666.67	4893977000	60196809370	-3.978E+09	1.56E+09	6.9E+10	11345697	8962341
100455666.7	7979198333	59696348950	-4.27E+09	1.63E+09	6.76E+10	11193341	8696078
0	0	30874045870	6894948483	5.48E+08	4.9E+10	8285950	6106337
0	0	33133194490	7161443786	7.33E+08	5.18E+10	8758082	6443245
0	0	37148024860	5114400392	1.51E+09	5.53E+10	9742624	7099679
0	0	42507302020	4220248626	1.97E+09	6.13E+10	10959872	7806830
0	0	47740715230	3865736274	2.43E+09	6.74E+10	11930028	8402180
0	0	53614470790	3037158405	2.89E+09	7.36E+10	12689418	8869951
0	0	59467087800	1935181211	3.38E+09	7.93E+10	13157974	9210878
0	0	65089404510	907574490	4.02E+09	8.48E+10	13459986	9423901
0	0	74067977700	65651579.8	4.69E+09	9.39E+10	13872232	9550357
0	0	81276948460	-248571578	5.37E+09	1.02E+11	14478796	9609625
0	0	86165767690	-481563299	6.06E+09	1.07E+11	15094255	9618958
0	0	29596083800	4777850700	5.32E+08	4.63E+10	8950428	6313233
0	0	32480035400	6918580200	7.48E+08	5.24E+10	9664651	6885117
0	0	39493257100	7144479100	8.55E+08	6.14E+10	10993034	7984993
0	0	42677379000	5614802400	4.55E+08	6.38E+10	11970619	8989430
316645900	3089636300	29327171000	3225675200	3.33E+08	4.44E+10	9835121	7707130
2422931400	10527017400	21171744300	1759150800	99106100	3.35E+10	10374127	8562131
5095818300	16985182600	14495744600	2258294700	88768800	2.76E+10	10827643	9054788
7895301900	18000532100	8290314000	1204390700	84219300	2.02E+10	10938404	9356065
9787142700	18404618500	3568871200	356313300	81037400	1.47E+10	11080860	9644234
11407319100	18565512200	-396494300	-316920700	78039900	1.01E+10	11240519	9908333
12639289900	18560994000	-3347244900	-514697800	76554200	6.98E+09	11425757	10157225
0	0	29596083800	4777850700	5.32E+08	4.63E+10	8950428	6313233

0	0	32480035400	6918580200	7.48E+08	5.24E+10	9664651	6885117
0	0	39493257100	7144479100	1.08E+09	6.16E+10	10993034	7984993
0	0	44837617900	5751522800	1.03E+09	6.7E+10	12268201	9087305
0	554381800	39322943600	3703282200	6.48E+08	5.62E+10	10814857	8372249
254794900	4720187600	33453629700	3108234400	3.19E+08	4.9E+10	11430567	9183179
2866992500	12478443700	22896697100	2573671100	4.17E+08	3.78E+10	11578524	9526728
5957084500	17682157700	17228383900	2485481400	3.76E+08	3.23E+10	12033261	10037675
7305074700	19369549700	14328994100	1629933700	3.73E+08	2.88E+10	12426462	10500535
8821674400	20567955200	10742908600	657119900	1.1E+08	2.41E+10	12670620	10843636
10637467800	21130234200	6260073100	141763200	3.09E+08	1.92E+10	12737918	11042824
0	0	29596083800	4777850700	5.32E+08	4.63E+10	8950428	6313233
0	0	32480035400	6918580200	7.48E+08	5.24E+10	9664651	6885117
0	0	39493257100	7144479100	1.15E+09	6.17E+10	10993034	7984993
0	0	45038009600	5767258100	1.24E+09	6.75E+10	12305752	9099834
0	2850000	43900313000	4174156800	1.18E+09	6.29E+10	11580485	8848924
0	404552900	43170493200	3717618900	1.08E+09	6.15E+10	12303306	9671239
0	756389300	43682796800	4365639000	1.19E+09	6.37E+10	13165761	10468250
0	2982843900	39840726500	3685950700	9.28E+08	5.91E+10	13586151	11007236
377485000	7454211100	35043513100	2510682300	8.14E+08	5.33E+10	14017275	11519289
1686761200	12738987400	31325724700	2386466200	7.07E+08	4.98E+10	14603967	12089257
3454191200	16334610000	28617158800	2631043300	8.04E+08	4.79E+10	15122359	12599470
		29596083800	4777850700	5.32E+08	4.63E+10	8950428	6313233
		32637746100	6923006200	7.48E+08	5.26E+10	9696905	6890739
		41088257200	7414449600	1.16E+09	6.39E+10	11340142	8111850
		49158915300	5841971200	1.3E+09	7.24E+10	12869535	9271320
		55239447900	4637857400	1.44E+09	7.89E+10	14145163	10273478
		60206473500	3794889500	1.53E+09	8.45E+10	15316645	11235351
		64222705700	3739589600	1.58E+09	8.98E+10	16404087	12158780
		68480647900	3312017800	1.64E+09	9.5E+10	17491047	13071485
		72728153200	2843305300	1.71E+09	1E+11	18562328	13976418
		77572247000	2564936400	1.8E+09	1.06E+11	19618343	14852001
		82558844400	2656121100	1.91E+09	1.13E+11	20656195	15696995
0	1813315031	32646976520	3128786018	9.41E+08	4.6E+10	10629113	8004550
63447843.84	2566112191	38638997820	1409787543	1.13E+09	5.3E+10	11076643	8546870
1558426104	9776825449	24755425680	-933615185	2.48E+08	3.69E+10	10898958	9323329
3650670817	15773641440	16421459180	-97235951	2.45E+08	2.91E+10	11688874	10187774
6237648239	20061980980	9512715803	2368667435	2.6E+08	2.24E+10	12420963	10952498
9532677330	23252746750	1645026937	5021001216	2.74E+08	1.48E+10	13252447	11806898
12663301320	24568908850	-6162634035	6039512586	2.86E+08	7.04E+09	13988388	12559384
15684998540	24992356640	-1.354E+10	2917535882	2.97E+08	-4.1E+08	14395245	12962068
18705289100	26883717840	-2.0063E+10	971396780	3.11E+08	-7.2E+09	14382531	12918876
23713467510	31790895160	-2.7729E+10	184772631	3.33E+08	-1.5E+10	14545515	13017220
0	1813315031	32646976470	3128786018	9.41E+08	4.6E+10	10629113	8004552
63447844.36	2566112191	38638996080	1409800650	1.13E+09	5.3E+10	11076644	8546871
513836331.3	5407643142	36025535260	-1.004E+09	4.87E+08	4.91E+10	11202337	9371571

1343569877	9527415052	29180102130	-1.081E+09	3.51E+08	4.27E+10	11865218	10168825
2690606140	13947034730	20523568250	-583822575	2.63E+08	3.4E+10	12493815	10904899
5005424528	17825592420	12739333940	2059411062	2.7E+08	2.65E+10	13178919	11643347
8040044438	20762954210	5007923513	5239011074	2.78E+08	1.88E+10	13906228	12412662
11206577020	23018415630	-3082679635	5856200199	2.87E+08	1.07E+10	14614628	13153508
14205855820	24003471600	-1.0817E+10	3685234328	2.95E+08	2.88E+09	15071887	13620484
17146466380	25722261680	-1.7439E+10	1477333711	3.05E+08	-4E+09	15110869	13635039

0	1813315031	32646976430	3128786018	9.41E+08	4.6E+10	10629113	8004552
63447844.36	2566112191	38638995160	1409800650	1.13E+09	5.3E+10	11076644	8546871
319340722.8	4402635891	39924554130	-473467893	8.31E+08	5.38E+10	11499234	9458487
728805740.2	6754661587	37337668670	-771584391	5.85E+08	5.17E+10	12143385	10250332
1387229395	9971512924	30044859920	-1.01E+09	3.91E+08	4.43E+10	12723870	10988598
2660596055	13571520230	21167666660	312778505	2.72E+08	3.54E+10	13271694	11641311
4684329802	16665978370	13312564610	2402792751	2.76E+08	2.75E+10	13894998	12330426
5416087424	17101215690	11488394390	-556876893	2.79E+08	2.62E+10	14634682	13072416
5883447851	17499026790	9928128253	-145536010	2.79E+08	2.49E+10	15205340	13657785
7025113686	18194774700	6446823513	1247195656	2.78E+08	2.16E+10	15759038	14237441

0	1813315031	32646976430	3128786018	9.41E+08	4.6E+10	10629113	8004552
63447844.36	2566112191	38638995000	1409800650	1.13E+09	5.3E+10	11076644	8546871
177727733.4	3772848009	45160886470	959892051	2.65E+09	6.29E+10	13014814	9627683
299785137.6	4858995410	47483618380	1511267258	2.9E+09	6.64E+10	13953231	10531886
401609317.9	5746969603	47525229300	1529462049	2.76E+09	6.67E+10	14547569	11419394
548962041.3	6634781779	46201039890	1411483434	2.24E+09	6.5E+10	14982018	12156491
663957157.8	7221827363	43627608290	963407382	1.58E+09	6.17E+10	15251950	12839312
827545261.7	7914499770	37408773430	-603009879	9.51E+08	5.46E+10	15396403	13422229
1110128254	8904439154	30242028090	-1.677E+09	5.21E+08	4.68E+10	15676960	13883899
1686669882	10428045430	22476442520	-1.907E+09	3.5E+08	3.87E+10	16009754	14343027

0	0	29385721490	2501447876	7.57E+08	4.42E+10	9925504	7349251
0	0	32646988710	3128786018	9.41E+08	4.91E+10	10629113	8004552
0	0	40417488040	1218539006	1.75E+09	5.73E+10	11701522	8611060
0	0	47694335230	1375235017	2.77E+09	6.77E+10	13174145	9657130
0	0	51591229000	2255699817	3.1E+09	7.44E+10	14429187	10596362
0	0	53078258600	2586178806	3.33E+09	7.73E+10	15602554	11531024
0	0	53691959560	3262017104	3.46E+09	7.94E+10	16613990	12330270
0	0	52929922310	2968286161	3.54E+09	7.91E+10	17606023	13121766
0	0	49420809640	1752113352	3.56E+09	7.45E+10	18493649	13882043
0	0	46575217220	957501541	3.54E+09	7.1E+10	19312971	14520689
0	0	44329322090	455399639	3.51E+09	6.97E+10	20173531	15168227
0	0	29550000000	5733000000	6.73E+08	4.76E+10	9813947	7167947
0	0	32200000000	4170000000	8.7E+08	5E+10	10277903	7844903

168000	702000	38370000000	1321000000	1.41E+09	5.45E+10	10769411	8602411
5900000000	6940000000	36130000000	1643000000	9.09E+08	4.92E+10	9806412	8081412
66000000000	71700000000	177300000000	4408000000	1.87E+08	3.19E+10	10855107	9145107
161000000000	168000000000	-38930000000	5147000000	1.49E+08	1.08E+10	12740634	10870634
192000000000	199000000000	-1.416E+10	1317000000	1.53E+08	-3.8E+09	12543652	10623652

20500000000	21000000000	-1.711E+10	859900000	1.77E+08	-7.6E+09	12002279	9982279
21600000000	21700000000	-1.863E+10	704400000	1.78E+08	-9.5E+09	12187886	9997886
22100000000	22200000000	-1.945E+10	-102300000	1.72E+08	-1.2E+10	11728601	9438601
22500000000	22500000000	-2.011E+10	-1.201E+09	1.83E+08	-1.4E+10	11234967	8914967
0	0	29550000000	5682942500	6.73E+08	4.76E+10	9806726	7160726
0	0	32200000000	4135005000	8.7E+08	5E+10	10300588	7867588
168000	702000	38370000000	1182252300	1.41E+09	5.45E+10	10758180	8591180
134000000	369000000	41610000000	1548648300	9.09E+08	5.6E+10	10458312	8638312
1700000000	4010000000	35770000000	2248976700	1.87E+08	4.86E+10	9976049	8334049
7430000000	12000000000	21150000000	3832273800	1.49E+08	3.51E+10	10483699	8973699
14000000000	18900000000	37840000000	3699276800	1.53E+08	1.72E+10	11884582	10424582
17200000000	21300000000	-62300000000	2240670400	1.77E+08	5.36E+09	12075051	10555051
19400000000	21600000000	-1.242E+10	1072327500	1.78E+08	-2.8E+09	11786224	10096224
21000000000	21900000000	-1.7E+10	507444100	1.72E+08	-8.6E+09	11720263	9720263
22100000000	22600000000	-1.918E+10	202014800	1.83E+08	-1.1E+10	11547910	9297910
0	0	29550000000	5682942500	6.73E+08	4.76E+10	9806726	7160726
0	0	32200000000	4135005000	8.7E+08	5E+10	10300588	7867588
168000	702000	38370000000	1170850200	1.45E+09	5.46E+10	10758180	8591180
43300000	279000000	43100000000	1375965000	1.12E+09	5.87E+10	10718811	8808811
477000000	3050000000	42640000000	887087500	5.64E+08	5.58E+10	10421960	8614960
2020000000	10700000000	36800000000	620238200	1.49E+08	4.8E+10	9272135	7616135
5780000000	17300000000	26140000000	2314157200	1.53E+08	3.85E+10	9587742	8162742
10200000000	20800000000	13000000000	2511429100	1.77E+08	2.52E+10	10485312	9075312
14900000000	21900000000	612200000	2136193000	1.79E+08	1.18E+10	10943469	9383469
19400000000	22300000000	-9651000000	1115723200	1.73E+08	-1.7E+08	11441236	9681236
21100000000	22500000000	-1.386E+10	260597600	1.84E+08	-6.1E+09	10800801	8920801
0	0	29550000000	5682942500	6.73E+08	4.76E+10	9806726	7160726
0	0	32200000000	4135005000	8.7E+08	5E+10	10300588	7867588
168000	702000	38370000000	1163470000	1.53E+09	5.46E+10	10758180	8591180
35400000	256000000	43570000000	1369095600	1.8E+09	5.99E+10	10786199	8836199
380000000	2620000000	45130000000	869293100	1.45E+09	5.99E+10	10679969	8778969
1600000000	10100000000	42910000000	316773000	9.49E+08	5.53E+10	9834250	7960250
4070000000	18500000000	36200000000	967689900	5.23E+08	4.8E+10	9523839	7889839
6500000000	22700000000	28510000000	973003200	2.88E+08	3.97E+10	9744845	8262845
8380000000	23300000000	22990000000	663049400	1.94E+08	3.32E+10	9723995	8256995
10100000000	22800000000	16910000000	260311100	1.87E+08	2.59E+10	9464186	7939186
10800000000	22800000000	15840000000	16737200	2.06E+08	2.35E+10	8828340	7265340
0	0	29550000000	5682942500	6.73E+08	4.76E+10	9806726	7160726
0	0	32200000000	4135005000	8.7E+08	5E+10	10300588	7867588
168000	702000	38370000000	1181359500	1.57E+09	5.47E+10	10758180	8591180
5960000	132000000	46480000000	1355990100	2.25E+09	6.42E+10	11101755	8981755
55300000	1570000000	53380000000	1135741600	2.38E+09	7.12E+10	11339988	9199988
219000000	7460000000	58060000000	111771300	2.4E+09	7.41E+10	10537639	8379639
513000000	17000000000	58930000000	6160700	2.33E+09	7.38E+10	10118517	8046517
910000000	22800000000	55220000000	81195200	2.46E+09	6.92E+10	9713114	7736114
1420000000	24000000000	50330000000	210237300	1.63E+09	6.23E+10	9330693	7403693
2100000000	23800000000	44090000000	94111100	8.34E+08	5.39E+10	8630530	6760530

2810000000	23800000000	40980000000	-20562300	8.47E+08	4.96E+10	7872276	6072276
0	0	29550000000	5732640500	6.73E+08	4.76E+10	9813947	7167947
0	0	32200000000	4171124600	8.78E+08	5E+10	10277903	7844903
0	0	39550000000	5062389300	1.73E+09	6.04E+10	11994362	9364362
0	0	51160000000	5566452000	2.5E+09	7.53E+10	12889186	10149186
0	0	65840000000	4025617000	2.89E+09	9.14E+10	13578425	10648425
0	0	82130000000	2306466100	3.44E+09	1.08E+11	13317114	10177114
0	0	1.012E+11	150416400	4.1E+09	1.26E+11	13529877	10409877
0	0	1.177E+11	-238674100	4.83E+09	1.43E+11	13484531	10344531
0	0	1.296E+11	-147852200	5.11E+09	1.55E+11	13483656	10163656
0	0	1.309E+11	-495368200	4.96E+09	1.54E+11	13225089	9775089
0	0	1.276E+11	-1.53E+09	4.7E+09	1.49E+11	12723682	9243682

Ammonia emissions	NOx emissions	Organic carbon emissions	Sulfur emissions	VOC emissions	Freight transport energy	Passenger transport energy	Final energy	Final energy (electricity)	Final energy (gases)
57252530	1.33E+08	34307961	1.17E+08	1.56E+08	23586.44	51535.72	94659.94	14858.6	14632.81
63370296	1.33E+08	36628929	1.2E+08	1.61E+08	24706.31	52415	102022.6	17600.12	15088.05
65452771	1.12E+08	29281071	77310097	1.19E+08	31615.94	68243.55	96283.46	20475.07	16039.61
64920241	62378103	19670691	33131302	73392567	33417.13	68646.8	76348.26	19542.79	15204.95
65249185	46320523	19580160	18772619	76607723	41927.66	88176.82	80272.37	23141.35	15747.12
64527895	36245009	15823020	15778996	80854920	48817.4	106733.8	89059.29	30641.08	15049.48
63767207	33596395	15123670	14515230	83718705	54692.62	120896	95645.38	37951.31	13186.74
63494497	32540362	14640320	13013372	76982286	59254.58	131040.6	100209.5	43505.45	10885.3
63336046	30991118	13917360	10974212	60431515	62292.56	137685.2	101952.5	46522.01	8630.86
62943553	29108899	13006560	8707670	44897979	64143.62	140115.9	101123.5	47118.15	7354.334
62757524	28354803	12274840	6544224	33902567	65302.4	138994.6	98795.75	45633.04	6714.7
57252530	1.33E+08	34307961	1.17E+08	1.56E+08	23586.44	51535.72	94659.94	14858.6	14632.81
63370296	1.33E+08	36628929	1.2E+08	1.61E+08	24706.3	52415	102022.5	17600.12	15088.04
65458926	1.24E+08	29974100	92217560	1.29E+08	32350.74	69550.39	107002.5	22776.54	18417.54
64550449	91244644	20448059	51781521	93529834	39975.9	87041.42	110755	28327.47	23071.78
64046095	78481323	18729111	34236938	96492814	47462.24	104368.6	115322.2	33304.81	27958.41
63919444	63132701	17063910	24878540	1.03E+08	53708.36	118513.3	118909.4	37998.11	29122.11
63100295	56529266	16008030	20117041	1.06E+08	58802.96	129721.4	123071.6	43596.95	27758.91
62970935	49586587	16021749	16614031	94495153	62676.46	137779.2	122295.9	47413.73	24164.74
63262780	40977950	15224790	12700078	71209128	65360.46	142016.4	118157.4	49492.98	18862.07
63821339	36089663	14762580	9756788	52171577	67435.57	143146.7	115136.3	49645.6	14644.86
62568349	32438861	12643560	7383750	38393875	67079.69	140685.4	115780.5	53329.99	13755.99
57252530	1.33E+08	34307961	1.17E+08	1.56E+08	23586.44	51535.72	94659.94	14858.6	14632.81
63370296	1.33E+08	36628929	1.2E+08	1.61E+08	24706.3	52415	102022.5	17600.12	15088.04
65520294	1.26E+08	30174271	95622780	1.31E+08	32481.98	69769.05	109755.1	23377.29	18959.58
64974828	98959306	21692101	61189461	1.01E+08	40423.25	87962.43	119694.2	30677.19	25216.47
64492434	90786752	20089540	49187481	1.09E+08	48334.61	106415.7	131117.5	37969.53	32381.58
64058055	74827147	17549589	37063622	1.18E+08	54748.36	121437.7	140196.6	44335.17	35513.36
63056418	66913640	16557261	29915880	1.22E+08	59637.85	132831.4	145207.5	50130.07	35455.67
62496617	56615356	15924560	22333780	1.08E+08	62963.59	140145.9	141900.9	53482.63	31213.8
62231384	45110950	15013320	15266986	79972764	64871.04	143574.4	132101.5	54597.9	23939.9
62950149	37872851	14343660	10582134	56920318	66684.02	143852.4	123895.5	53973.02	16058.9
63693268	34950701	14584560	7790372	43016641	67014.65	141101.3	120611.1	54556.77	12337.23
57252530	1.33E+08	34307961	1.17E+08	1.56E+08	23586.44	51535.72	94659.94	14858.6	14632.81
63370296	1.33E+08	36628929	1.2E+08	1.61E+08	24706.3	52415	102022.5	17600.12	15088.04
65725726	1.27E+08	30750540	95745659	1.32E+08	32489.09	69774.67	109744.3	23408.55	18852.5
65550721	1.01E+08	23389009	63506741	1.04E+08	40499.54	88084.35	121362.8	31120.41	25716.46
65022605	97138591	21508751	58428501	1.15E+08	48581.52	106896.7	137205.5	39774.45	34343.5
64397584	84188545	18172899	53150921	1.26E+08	55153.21	122268.5	150270.2	47613.12	38281.28

63110841	76333484	16355860	45285702	1.3E+08	60158.14	133891.7	157331.4	54619.82	39255.53
62486892	65074061	15682000	34398121	1.16E+08	63684.91	141450.1	156565.2	59165.46	36450.33
62148963	50963826	14902050	23519899	88201717	65473.13	144820	149285.3	61707.27	31419.8
61770513	39635110	13914040	14746346	63454505	66243.93	144604	138859.1	62168.6	24951.27
60931843	32617609	12258870	9688266	45158742	66217.85	141534.4	130142.7	61799.75	19391.44
57252530	1.33E+08	34307961	1.17E+08	1.56E+08	23586.44	51535.72	94659.94	14858.6	14632.81
63370296	1.33E+08	36628929	1.2E+08	1.61E+08	24706.3	52415	102022.5	17600.12	15088.04
65915706	1.27E+08	31225559	95878540	1.33E+08	32493.46	69777.97	109794	23418.94	18869.04
66816046	1.04E+08	27416611	64427422	1.1E+08	40513.88	88103.35	121699	31192.39	25602.83
66041586	99984813	24607969	60487122	1.2E+08	48650.55	107025.5	138926.4	40269.2	34794
64791848	86621157	19053640	56424320	1.29E+08	55227.02	122425.2	152111.1	48279.37	39286.62
63130712	80452327	16092541	53727020	1.32E+08	60305.7	134154.8	161444.9	56139.49	40852.12
62523007	72084926	15416780	48621479	1.21E+08	63931.41	141883.8	165289.8	62528.64	39416.23
62164095	58645301	14677250	38789501	93792450	65965.62	145499.3	162777	67373.86	36026.22
61667248	46631548	13403940	28824760	67539198	66963.79	145521.6	156012.6	69612.22	31649.91
60712022	37471568	12041380	19804228	47907949	66733.94	142455.2	146752.7	69404.42	27420.28
53311985	1.18E+08	32788420	1.08E+08	1.92E+08			89745.07	15054.18	13385.57
55391244	1.12E+08	32779763	1E+08	1.88E+08			100480.9	17704.18	14593.62
49017490	1.04E+08	30234324	76406009	1.78E+08			121880.1	22761.13	15362.23
47190186	79802280	28237975	39257572	1.67E+08			117732.9	27124.47	15032.23
44647999	62598875	25958219	27407723	1.53E+08			116718.7	36957.53	19607.24
40612011	53912909	23561260	24649652	1.38E+08			121697.9	49233.65	27382.52
36762506	50982523	21056046	23015668	1.28E+08			131503.2	59522.83	30903.08
33839254	48509417	18509965	20838205	1.18E+08			140739.8	68928.94	29720.3
31744079	46160086	15928535	18938202	1.06E+08			150369.6	77530.06	28482.52
30264763	43669903	14011262	17201823	96324705			160087.9	85765.07	28383.91
29157855	41740367	13209558	16087878	92070142			171726.2	94928.13	30385.86
53311879	1.18E+08	32788517	1.08E+08	1.92E+08			89733.41	15054.18	13385.57
55391080	1.12E+08	32779506	1E+08	1.88E+08			100512.3	17704.18	14593.35
47446506	1.03E+08	30253298	76106893	1.78E+08			121818.4	22815.3	15148.07
48613481	90562273	28456995	54884506	1.72E+08			132648.4	28230.02	14999.73
48340300	76704356	26418585	35557614	1.62E+08			140093.2	34778.08	18632.24
46932245	65223686	24170570	26997506	1.47E+08			145913.5	44497.26	25524.19
44995728	60881793	21723496	25752987	1.35E+08			155615.1	55736.43	32853.08
41757230	58818169	19280390	25423773	1.22E+08			165121.2	68336.72	42996.42
38142461	55976980	16797840	24776132	1.12E+08			176510.7	79495.9	46069.76
35227297	52472877	14834049	22279189	1.02E+08			187570.7	90554.52	46498.09
32943961	48956111	13964566	19593698	96034253			201186.5	102640.4	48790.04
53311879	1.18E+08	32788517	1.08E+08	1.92E+08			89733.41	15054.18	13385.57
55391081	1.12E+08	32779500	1E+08	1.88E+08			100512.3	17704.18	14593.35
48538528	1.04E+08	30205917	76394847	1.78E+08			121829	22773.07	15547.23
51478546	98758745	28502199	65058482	1.74E+08			138625.4	28114.47	15868.35
52411875	86249560	26552324	49420869	1.67E+08			152290.4	34061.42	18700.57
51215310	77160040	24424562	39086969	1.56E+08			162528.2	41879.48	23675.85
49656583	68443039	22073453	32546421	1.41E+08			169619.9	52357.26	31235.86
47475218	63654822	19611427	27386266	1.29E+08			182018.2	61355.05	44325.87
45042846	59940277	17073827	25101105	1.15E+08			194610.4	72820.06	57093.1

42717643	57513421	15244832	25077999	1.07E+08	206192.1	86860.9	61043.94
39714351	54961487	14515687	24495394	1.04E+08	221311.6	100799.5	62219.22
53311879	1.18E+08	32788517	1.08E+08	1.92E+08	89733.41	15054.18	13385.57
55391078	1.12E+08	32779500	1E+08	1.88E+08	100512.3	17704.18	14593.35
48907312	1.04E+08	30183053	76779945	1.78E+08	122049	22733.63	15488.62
52915679	1.01E+08	28506840	72012877	1.75E+08	141517.3	28243.08	15528.07
55230967	90414941	26605900	59622242	1.68E+08	158485.7	34032.25	18074.74
55558188	83246750	24472385	48491201	1.59E+08	171562.4	41637.26	21857.8
54612257	76873134	22232003	42770105	1.46E+08	180952.9	51827.82	25827.24
52417313	71389706	19908906	38527958	1.34E+08	192411	61407.27	34360.03
49918622	66600884	17426649	34058628	1.21E+08	206954.1	69653.67	50415.04
47652420	61113035	15458670	28036548	1.09E+08	221569.1	79420.62	67280.61
45776741	58002888	14609433	24866807	1.03E+08	237571.9	92735.91	78309.23
53311879	1.18E+08	32788527	1.08E+08	1.92E+08	89733.41	15054.18	13385.57
55391081	1.12E+08	32779500	1E+08	1.88E+08	100512.3	17704.18	14593.35
49241564	1.04E+08	30197707	76941086	1.78E+08	122102	22733.63	15355.85
53855443	1.02E+08	28753617	77071207	1.75E+08	143212.9	28446.97	15426.68
57446165	94028460	26741032	68892340	1.69E+08	161666.2	34363.08	18080.29
60132049	88039094	24657581	59987498	1.61E+08	176647.1	41805.03	21503.35
61737246	83144982	22420164	55433520	1.49E+08	189505.2	52336.71	23460.57
60338393	77391872	20041463	49114445	1.38E+08	201934.3	63371.44	25856.41
58630678	74591867	17671837	45855792	1.31E+08	219801.6	71919.78	27739.74
57401985	71245470	15869921	42844127	1.26E+08	239946.9	79891.45	27687.24
55790124	67281343	15095103	38963058	1.23E+08	261107.7	89140.9	29776.97
53311876	1.18E+08	32788520	1.08E+08	1.92E+08	89732.57	15054.18	13385.57
55391055	1.12E+08	32779484	1E+08	1.88E+08	100512.3	17704.18	14593.35
50094262	1.04E+08	30278136	77969162	1.78E+08	122313.4	22744.74	15444.73
54419642	1.03E+08	28686193	79198786	1.75E+08	144246.5	28622.52	15585.57
57800607	95724742	26795279	72288668	1.69E+08	163101.8	34383.36	18290.01
60676602	90067498	24789173	65157221	1.61E+08	178869.9	41843.37	21045.02
62749454	85687352	22617675	61169703	1.51E+08	192858.2	52368.93	22503.07
63778857	80530130	20294772	56309629	1.4E+08	207202.9	64114.77	23571.96
63859411	78658440	17954287	52964512	1.33E+08	226423.8	72892.28	24515.02
64738704	76236743	16175726	48530784	1.29E+08	247655.5	81091.45	24571.69
65407187	72884597	15470049	43897887	1.27E+08	270511.9	91264.24	24693.91
52609600	1.23E+08	38066200	1.19E+08	2.1E+08	92822.52	15178.76	14949.96
53595900	1.16E+08	36648800	99761100	2.06E+08	100320.3	17068.46	16076.65
55837600	1.24E+08	36374300	1.03E+08	2.12E+08	122808.3	21168.18	20660.18
58200800	1.22E+08	35672600	97845100	2.11E+08	139833.6	25029.41	24878.27
58128100	84629400	31637800	55125400	1.94E+08	128419.6	27222.02	21236.24
58341600	75016500	30100700	43142000	1.91E+08	133181.1	32009.75	21316.68
58546400	69024900	28433500	35947700	1.85E+08	137015.1	37609.64	20945.74
57819500	62548700	26883100	30470400	1.76E+08	137568.9	44921.87	17997.38
57460300	57834500	25676200	26245000	1.68E+08	139328.4	52383.65	15229.76
57356100	54710500	24636400	22875100	1.6E+08	143110.5	60499.02	12845.45
57507800	53184300	23739700	20256000	1.53E+08	149298.1	68868.86	11055.18
52609600	1.23E+08	38066200	1.19E+08	2.1E+08	92822.52	15178.76	14949.96

53595900	1.16E+08	36648800	99761100	2.06E+08			100320.3	17068.46	16076.65
55837600	1.24E+08	36374300	1.03E+08	2.12E+08			122808.3	21168.18	20660.18
58248700	1.25E+08	35727000	1E+08	2.12E+08			143372.9	25601.91	25617.02
59109100	1.03E+08	32763100	72692800	2.01E+08			143206.4	27329.66	26629.88
59547900	91637600	30944900	58983900	1.97E+08			147128.4	29761.13	28493.69
59223100	78480900	28645700	43693800	1.89E+08			146801.5	34978.08	27399.88
59524000	74503800	27185500	37680300	1.83E+08			151240.1	38595.81	28200.44
59645300	71212000	25812900	33973600	1.76E+08			155017.3	43532.09	27915.55
59688200	67368900	24554500	29944000	1.69E+08			158460	49708.87	26199.24
59570600	63252300	23419300	25745100	1.61E+08			161540.5	57455.63	22983.3
52609600	1.23E+08	38066200	1.19E+08	2.1E+08			92822.52	15178.76	14949.96
53595900	1.16E+08	36648800	99761100	2.06E+08			100320.3	17068.46	16076.65
55837600	1.24E+08	36374300	1.03E+08	2.12E+08			122808.3	21168.18	20660.18
58252900	1.25E+08	35732800	1.01E+08	2.12E+08			143649.5	25683.58	25637.99
59506700	1.12E+08	33483000	82974200	2.05E+08			149753.6	28275.3	28278.52
60232900	1.06E+08	31824000	74715900	2.02E+08			156329.5	30941.14	31356.97
60712800	1.03E+08	30120300	70425800	1.97E+08			164031.6	33647.83	35891.67
60723500	96056400	28190600	61024800	1.9E+08			168505	35874.72	38691.56
61023800	89474000	26447600	52701200	1.84E+08			172716.4	38963.86	40542.45
61625200	85773000	24998000	46939700	1.78E+08			179838.7	43278.06	42581.53
62145300	83214300	23602600	42348100	1.72E+08			187754.9	48715.62	44083.67
52609600	1.23E+08	38066200	1.19E+08	2.1E+08			92822.52	15178.76	14949.96
53601600	1.17E+08	36655400	1E+08	2.06E+08			100497.1	17064.6	16088.96
55882500	1.29E+08	36445300	1.07E+08	2.12E+08			124576.8	21593.43	20729.27
58365700	1.33E+08	35836900	1.07E+08	2.14E+08			146030	26786.08	25797.47
60405900	1.35E+08	35204500	1.07E+08	2.12E+08			161166.6	31701.41	29765.47
61905000	1.36E+08	33860900	1.06E+08	2.12E+08			172053.1	37178.36	33548.42
62862300	1.33E+08	32100900	1.02E+08	2.08E+08			180299.3	41435.34	37965.09
63575200	1.3E+08	30451900	98786500	2.03E+08			188529.4	45668.59	41383.45
64319100	1.26E+08	28853900	95054400	1.98E+08			196848.6	50095.6	44652.34
65200300	1.23E+08	27370500	89455300	1.93E+08			206498.9	54668.4	47816.12
66126900	1.19E+08	25897700	82541000	1.88E+08			216383.2	59620.3	51081.6

52338447	1.09E+08	36065237	1E+08	1.54E+08	27877.41	63560.13	109403.3	18254.26	17649.46
61761490	1.11E+08	31858344	96043410	1.7E+08	39066.31	77057.51	131621.5	25795.87	19939.02
68042818	82431063	32820865	55153636	1.59E+08	47765.41	87313.47	138656.3	36620.52	19956.54
73237931	67842202	33672877	38644663	1.57E+08	56267.85	95279.86	148863.3	47299.79	20136.4
77084917	59648453	34710961	30907309	1.58E+08	61922.93	99909.97	154096.1	57885.04	18786.45
79766916	51747872	32744791	26126558	1.51E+08	64986.83	101862.5	156283.4	67181.41	16914.93
81349299	44730093	29869102	23140201	1.41E+08	66671.15	101693.2	156989.9	75007.42	14876.13
80324017	34085085	22632578	20362663	1.2E+08	66968.51	100026.2	156418.1	81090.15	12855.88
76576647	25777406	18172266	18908764	1.04E+08	66885.15	97310.17	155947	86297.02	10970.26
74157414	19729080	14907335	18729518	94551638	67462.36	93697.56	158428.9	92748.88	9322.643

52338447	1.09E+08	36065238	1E+08	1.54E+08	27877.41	63547.16	109403.3	18254.26	17649.46
61761490	1.11E+08	31858335	96043408	1.7E+08	39031.56	77082.48	131621.5	25795.87	19939.02
68518057	98721750	31852399	75661714	1.67E+08	49498.26	88249.5	145305.9	33867.23	22190.13

73786023	82929168	32075639	57008450	1.63E+08	58859.77	96825.54	156947.6	42658.74	23368.08
78076765	67333385	31355405	40527236	1.58E+08	65456.52	102210.6	162676.8	51591.64	22963.95
80836913	58193482	29820286	32174753	1.53E+08	69532.36	105148.2	164745.6	59947.97	21688.17
82943288	51205066	29906055	27248226	1.48E+08	72196.93	105990.6	164880.8	68327.58	19500.49
84209784	42535393	28338574	23427843	1.35E+08	72702.85	104808.7	163116.5	75287.2	17055.27
83300739	33584273	22712575	20888418	1.18E+08	72077.69	102329.8	160787.2	80691.22	14725.75
79757822	25706578	18095963	19373512	1.03E+08	71075.36	98815.94	159297.2	85531.99	12585.33
52338447	1.09E+08	36065238	1E+08	1.54E+08	27877.41	63547.16	109403.3	18254.26	17649.46
61761490	1.11E+08	31858335	96043408	1.7E+08	39031.56	77082.48	131621.5	25795.87	19939.02
68674078	1.04E+08	31412794	83522583	1.7E+08	50385.22	88700.69	148826.6	33075.88	23097.53
74228884	93730475	31397276	70266339	1.68E+08	60266.49	97548.41	161760.2	40771.17	24761.04
78753749	77965238	30308028	53429290	1.62E+08	67545.8	103315.7	168421.5	48267.86	25092.57
81508865	64708808	28272231	39815118	1.56E+08	72320.14	106789.4	171091	55348.44	24486.98
83768680	55675915	27485530	31560889	1.5E+08	75638.88	108247.3	171130.5	62958.68	22824.02
86251542	47002587	19467821	28459254	1.33E+08	79792.86	109631.6	173905.4	65682.64	23715.11
87771081	42475451	17910126	26719114	1.27E+08	83114.09	109935.1	174765.3	68163.62	23971.76
88838694	37930150	18473316	24626494	1.22E+08	84636.43	108844.6	173422.1	71577.39	23068.13
52338447	1.09E+08	36065238	1E+08	1.54E+08	27877.41	63547.16	109403.3	18254.26	17649.46
61761490	1.11E+08	31858335	96043408	1.7E+08	39031.56	77082.48	131621.5	25795.87	19939.02
68967840	1.1E+08	30892323	95051686	1.75E+08	51860.54	89365.2	154709.5	32885.9	23903.43
74676335	1.06E+08	30191319	89050302	1.76E+08	62697.15	98619.77	170470.1	39314.15	26239.07
79766105	97735576	29073850	80247739	1.74E+08	71370.58	104969.3	180331.2	44610.21	27622.8
83509746	90131870	26596503	72113049	1.71E+08	78104.83	109392.2	186468.1	48658.58	28510.69
86712501	81759932	24382476	62772873	1.65E+08	83766.57	112150.8	189528.6	52402.04	28901.38
89086445	67996945	21536499	49556399	1.53E+08	87630.64	113322.5	189441	55651.32	28818.69
89812289	57016247	19369327	39435531	1.41E+08	90254.04	113312.5	187402.9	59112.25	28415.3
90698042	47827677	18416347	32109073	1.31E+08	91603.71	112371.7	184553.6	62943.39	27795.91
46905961	1.12E+08	31285759	1.15E+08	1.55E+08	24644.52	53575.07	99737.11	15448.36	16015.22
52338447	1.09E+08	36065238	1E+08	1.54E+08	27877.41	63547.16	109403.3	18254.26	17649.46
61922658	1.13E+08	32187336	1E+08	1.73E+08	39505.89	77438.25	133627.9	26010.95	20478.81
69229225	1.13E+08	31316550	97979371	1.78E+08	52215.92	89510.29	155595.3	33166.02	23795.49
75042748	1.09E+08	30316383	93226039	1.79E+08	63284.48	98846.35	171863.1	39550.5	26168.08
80202546	1.02E+08	28603453	85534953	1.77E+08	72257.67	105288.1	182339.9	44761.42	27627.45
84079084	95453395	26590607	78806001	1.76E+08	79409.05	109857.4	189465.7	48456.42	28703.58
87793320	88151967	24242515	70946165	1.72E+08	85700.58	112834.6	193890.8	51643.71	29390.53
89826772	75915997	21255378	59432918	1.59E+08	90530.3	114350.8	195636.4	53872.95	29785.16
91577125	67313124	18919223	51448342	1.51E+08	94593.49	114865.3	196032.1	55663.28	30198.43
93354460	59735820	16786883	44291864	1.44E+08	98049.37	114752.1	196325.4	57118.9	30833.91
39337300	1.17E+08	29106100	1.14E+08	1.55E+08	85050	38050	91861.18	14861.12	14252.79
42243600	1.11E+08	27760700	94597200	1.52E+08	93100	41740	99000.08	17491.68	15766.68
49795600	1.13E+08	26096300	74469400	1.52E+08	134600	65450	125222.3	24369.46	20363.91
56015700	92643000	23067100	48171800	1.39E+08	167900	89580	137139	28944.47	14322.23
65023500	66677200	19562300	29076200	1.19E+08	162400	94110	132805.7	40138.92	10188.9
73552900	46048400	17471300	18508800	1.01E+08	162800	108100	142166.8	64638.94	7825.006
81449100	40572700	16579500	14767800	90694700	130700	133200	150277.9	89388.96	5988.894

86182200	38863100	15974300	13913200	86309100	120200	156600	170805.7	109611.2	5830.56
86967400	37946700	15615300	13672700	82635300	124100	187500	191166.8	126305.7	6244.449
87669100	35777500	15155300	13045900	78748400	125000	208500	209805.7	143500.1	6350.005
86862800	33145500	14853400	11879900	74809200	127400	237400	224694.6	156777.9	6202.783
39271500	1.17E+08	28982600	1.14E+08	1.55E+08	85050	38050	91861.18	14861.12	14252.79
42481200	1.11E+08	28399200	94702800	1.53E+08	93100	41740	99000.08	17491.68	15766.68
49648400	1.14E+08	26350000	74507300	1.52E+08	134600	65450	125222.3	24369.46	20363.91
55902200	99143900	23292100	50752200	1.4E+08	179600	94300	149694.6	32583.36	18972.24
60683500	78595200	20285200	34264100	1.25E+08	199000	108600	160722.4	42750.03	17494.46
67873100	55079600	18291700	22473200	1.12E+08	218800	126800	172777.9	59277.83	17522.24
77841500	48620200	17207900	16864100	98930600	223200	142000	175611.3	78972.29	15538.9
82780000	42591600	16573500	13399700	88636600	208000	159400	184833.5	100555.6	15194.46
85816600	37860300	16015900	11557200	83560300	183500	188600	198750.2	118527.9	13430.57
88170700	36005900	15668700	11943300	79408800	169500	203500	214250.2	137250.1	9677.786
87410300	34524900	15287800	12248000	75404200	163900	237000	229778	151194.6	9063.896
39271500	1.17E+08	28982600	1.14E+08	1.55E+08	85050	38050	91861.18	14861.12	14252.79
42481200	1.11E+08	28399200	94702800	1.53E+08	93100	41740	99000.08	17491.68	15766.68
49648400	1.14E+08	26350000	74514300	1.52E+08	134600	65450	125222.3	24369.46	20363.91
55669000	1.01E+08	23468400	53476100	1.4E+08	178500	94340	151166.8	34083.36	20619.46
59920100	83410200	20536300	36908700	1.27E+08	202900	110900	168666.8	44750.04	22227.8
63119000	59973200	18854100	25382000	1.15E+08	235200	133200	186944.6	59916.71	23619.46
69928100	54135000	17920400	19880600	1.05E+08	256700	151200	194694.6	75694.51	24008.35
75658900	47191200	17113500	15276500	92649600	250100	165700	199000.2	92305.63	26516.69
80005200	41027500	16437600	12135900	84649700	236000	193900	209333.5	112694.5	23600.02
83506300	36461100	16009700	10915600	79998600	218000	209400	221722.4	130833.4	17141.68
84517400	33119600	15641500	10102700	75947300	200800	236500	232861.3	144666.8	13152.79
39271500	1.17E+08	28982600	1.14E+08	1.55E+08	85050	38050	91861.18	14861.12	14252.79
42481200	1.11E+08	28399200	94702800	1.53E+08	93100	41740	99000.08	17491.68	15766.68
49648400	1.14E+08	26350000	74514300	1.52E+08	134600	65450	125222.3	24369.46	20363.91
55740300	1.02E+08	23546900	55425900	1.41E+08	179100	94590	152083.5	34305.58	20625.02
59923500	86381900	20734500	39816900	1.27E+08	205400	112200	173055.7	45055.59	23613.91
63321100	65216100	19062100	28100500	1.17E+08	242800	136800	196444.6	59388.94	27319.47
68969200	60091300	18290400	23111200	1.09E+08	276000	158000	210666.8	73055.61	29916.69
72888500	53993800	17588600	18558000	98530900	289500	173000	218750.2	87027.85	36194.47
74318900	48690000	17063000	15249400	89284200	311700	203900	233166.9	103305.6	39527.81
74962700	42480700	16506800	13220100	82409100	313900	223700	243861.3	118333.4	36861.14
73470300	37798900	16104100	11467400	77177000	330200	254700	258028	127722.3	40861.14
39271500	1.17E+08	28982600	1.14E+08	1.55E+08	85050	38050	91861.18	14861.12	14252.79
42481200	1.11E+08	28389200	94700800	1.53E+08	93100	41740	99000.08	17491.68	15766.68
49648400	1.14E+08	26350000	74508300	1.52E+08	134600	65450	125222.3	24369.46	20363.91
56245600	1.06E+08	23754000	60934900	1.41E+08	182600	95850	156166.8	35361.14	21933.35
59740000	94948700	21055700	50130800	1.29E+08	215500	116000	184666.8	47555.59	27236.13
62091800	75617100	19450000	36751700	1.2E+08	258600	143500	213222.4	60944.49	32444.47
65603700	72420800	18790000	29266700	1.15E+08	300400	167700	233722.4	70527.83	39000.03
67951500	65562600	18206100	23190700	1.06E+08	327000	183200	248028	80083.4	50361.15
68859500	58446200	17754700	18754200	97114100	364000	212600	261333.5	92972.3	56166.71
68540500	50456300	17305700	15771500	88150500	375000	231700	268472.4	108111.2	56638.93

66432700	43611100	16815600	13043000	81580700	387600	261500	279722.4	117777.9	63388.94
39337300	1.17E+08	29106100	1.14E+08	1.55E+08	85050	38050	91861.18	14861.12	14252.79
42243600	1.11E+08	27750700	94595200	1.52E+08	93100	41740	99000.08	17491.68	15766.68
49875500	1.17E+08	28145500	77239400	1.55E+08	135200	65570	125139	24908.35	18850.02
56405400	1.12E+08	25552200	65961300	1.44E+08	185800	96860	159805.7	35638.92	23175.02
60553900	1.05E+08	22302700	59927800	1.31E+08	225700	119500	197805.7	49583.37	34777.81
62747700	88065700	20332500	48566900	1.22E+08	274700	149700	232694.6	64861.16	42611.15
66896100	89181400	19431200	41758000	1.18E+08	328100	178700	261222.4	76138.95	50777.82
70696500	87537900	18737400	35218700	1.12E+08	368100	199300	285000.2	85750.07	61250.05
71354400	83521000	18304000	29339400	1.06E+08	425800	232200	307778	95694.52	66694.5
71355700	74865000	17733200	24667800	97176700	460700	250700	316944.7	105972.3	68166.72
69138500	63535500	17142000	18952800	87767600	485100	280100	324166.9	114416.8	75388.95

Final energy (heat)	Final energy (hydrogen)	Final energy (industry)	Final energy (liquids)	Final energy (residential/ commercial)	Final energy (solids)	Final energy (traditional biomass)	Final energy (transport)	Radiative forcing	Radiative forcing (aerosols)
3680.478	1.91E-06	28803.27	42149.23	32357.69	19338.83	10553.69	25079.37	1.870916	-1.11517
4083.709	0.10653	33812.83	42081.13	34022.74	23169.45	11266.13	24831.47	2.139458	-1.05053
3242.755	5.545885	32795.05	38729.98	30646.3	17790.49	5952.919	26012.24	2.582151	-0.88032
2030.806	2920.313	29913.39	22333.99	25876.74	14315.43	2981.283	17312.28	2.843904	-0.58559
1568.672	11819.6	31243.19	16198.48	27875.26	11797.13	2594.487	18288.08	2.791113	-0.48819
1401.934	15181.73	33728.69	14899.71	31751.84	11885.36	2290.657	19828.87	2.634877	-0.43835
1141.998	14935.96	35460.36	14791.12	35792.93	13638.25	1829.056	20318.33	2.469284	-0.42607
869.194	15211.33	35100.03	15143.24	39596	14594.96	1358.427	21380.41	2.336205	-0.41347
659.2483	16528.12	33468.11	14807.99	41591.39	14804.27	1036.26	22776.23	2.207992	-0.39178
481.8698	18754.32	30800.33	13741.91	42016.77	13672.91	735.7428	24254.54	2.068866	-0.36447
347.792	21858.62	27815.36	12478.16	41740.91	11763.46	446.8262	25411.49	1.905195	-0.34318
3680.478	1.91E-06	28803.27	42149.23	32357.69	19338.83	10553.69	25079.37	1.870916	-1.11517
4083.709	0.10653	33812.8	42081.13	34022.74	23169.43	11266.13	24831.47	2.135342	-1.05491
3732.17	4.049789	37248.45	42367.76	33462.53	19704.46	6417.03	28436.91	2.551068	-0.97582
3080.014	259.9785	39031.26	38356.62	35255.77	17659.14	3881.47	29422.52	2.931325	-0.7469
2463.71	879.2871	40590.61	33608.79	38006.7	17107.16	3474.336	31073.05	3.092123	-0.63699
2016.901	1229.747	40659.84	32251.64	40527.23	16290.89	2877.05	31288.22	3.124641	-0.55117
1529.622	2453.096	40877.56	31404.78	44107.35	16328.2	2267.683	31515.69	3.089988	-0.5054
1112.317	5111.401	38593.48	28946.26	46223.52	15547.47	1702.658	30962.47	3.024207	-0.47206
788.4087	12046.53	35338.81	22805.51	46370.19	14161.89	1261.484	30443.64	2.916334	-0.43055
573.5718	18890.22	31727.11	19011.63	46759.32	12370.47	877.8849	30899.8	2.769267	-0.39889
419.0526	18759.15	29105.64	19098.8	49642.17	10417.45	549.7346	30677.25	2.637267	-0.36004
3680.478	1.91E-06	28803.27	42149.23	32357.69	19338.83	10553.69	25079.37	1.870916	-1.11517
4083.709	0.10653	33812.8	42081.13	34022.74	23169.43	11266.13	24831.47	2.1344	-1.05592
3840.475	4.39467	38421.81	43353.23	34113.16	20220.1	6524.672	29090.5	2.568914	-0.99923
3373.128	260.7912	42617.23	40979.18	38009.59	19187.46	4207.931	31325.72	3.006489	-0.82262
2937.68	835.4843	45951.07	37768.45	43234.41	19224.79	3976.664	34612.11	3.270402	-0.75556
2494.568	943.6385	47432.62	37843.87	47632.21	19066.05	3418.961	36455.45	3.47776	-0.65081
1886.552	1505.033	47529.84	37339.03	51815.57	18891.19	2730.274	37286.11	3.602119	-0.58833
1328.265	2560.994	44643.73	35176.21	53267.49	18138.98	2036.958	36146.5	3.676591	-0.51882
904.3152	5693.841	39366.2	30215.88	52415.58	16749.67	1462.251	33515.64	3.660825	-0.45007
621.8869	13022.6	34508.28	24593.97	51103.74	15625.09	967.5258	32313.42	3.54306	-0.40562
450.7676	17667.53	30829.44	21880.4	51465.45	13718.4	563.2296	32400.11	3.383062	-0.3867
3680.478	1.91E-06	28803.27	42149.23	32357.69	19338.83	10553.69	25079.37	1.870916	-1.11517
4083.709	0.10653	33812.8	42081.13	34022.74	23169.43	11266.13	24831.47	2.13433	-1.05603
3840.792	4.395865	38428.39	43405.54	34080.27	20232.48	6525.575	29101.83	2.571433	-1.00275
3423.795	254.4227	43188.42	41593.97	38478.53	19253.75	4279.289	31705.58	3.021749	-0.84861
3095.419	840.0762	48082.9	39503.18	45199.08	19648.91	4186.184	35929.75	3.320321	-0.83175
2694.688	948.1271	51315.62	40261.71	51020.33	20471.27	3688.761	38640.33	3.597944	-0.77368

2055.109	1388.148	51391.76	39980.12	56265.3	20032.67	2989.461	39963.01	3.858525	-0.70532
1481.636	2210.044	48793.73	38178.37	59033.44	19079.31	2290.96	39437.81	4.079861	-0.61379
1039.058	3266.039	44392.28	34012.86	59442.94	17840.32	1721.051	37021.64	4.209114	-0.51556
705.6778	4444.017	39374.03	29997.59	57958.49	16591.9	1168.176	34088.28	4.268145	-0.42964
472.2423	6064.555	34688.28	27103.7	56366.41	15310.97	669.982	32327.47	4.270901	-0.3703
3680.478	1.91E-06	28803.27	42149.23	32357.69	19338.83	10553.69	25079.37	1.870916	-1.11517
4083.709	0.10653	33812.8	42081.13	34022.74	23169.43	11266.13	24831.47	2.134266	-1.05613
3841.55	4.399876	38440.23	43429.95	34094.98	20230.12	6526.647	29118.3	2.576915	-1.00585
3435.272	253.9158	43551.59	41600.03	38557.72	19614.6	4274.045	31766.05	3.067757	-0.87126
3143.208	846.7329	48861.82	39838.46	45716.08	20034.82	4230.42	36300.61	3.450918	-0.85968
2734.426	952.8746	51461.07	40798.21	51685.44	20059.62	3744.603	39070.92	3.798741	-0.80384
2112.892	1396.559	52752.52	40840.25	57722.52	20103.6	3068.519	40884.84	4.089258	-0.76863
1566.54	2291.281	51652.88	39740.05	62286.05	19747.01	2419.758	41255.51	4.366412	-0.72084
1128.275	3519.517	48529.74	35751.97	64888.58	18977.21	1892.147	39685.37	4.622711	-0.63436
786.5912	4903.179	44154.2	31610.84	65223.75	17449.83	1324.84	37484.06	4.833992	-0.54025
526.6532	6298.936	38979.34	28206.77	63725.27	14895.64	778.1809	35607.81	5.009074	-0.45371
3043.891	0	32468.36	39848.37	33208.36	18331.68	8144.729	24068.07	1.870916	-1.11517
3206.391	0	37503.36	41997.81	36444.47	22360.02	8473.062	26533.35	2.137667	-1.05306
3720.836	0	46014.76	53367.82	42347.81	24216.96	7867.229	33517.53	2.623028	-0.93934
5946.949	530.8338	42955.31	44118.09	41591.98	19800.85	7269.728	33185.58	2.997782	-0.70567
7112.783	1905.835	42669.48	28662.52	42681.15	14741.12	6240.838	31368.08	3.001046	-0.59917
6928.061	2638.613	45286.43	13303.07	45406.7	13131.95	5005.004	31004.75	2.847006	-0.55885
5710.282	4226.67	47681.15	11886.4	49307.26	9185.563	3635.836	34514.47	2.672744	-0.53856
5375.838	4564.448	49105.87	17363.63	54338.1	3928.892	2247.502	37295.86	2.487768	-0.51761
5936.671	4615.837	50878.93	20488.63	59796.99	2000.279	750.5562	39693.64	2.281985	-0.49729
6578.339	4625.559	52285.88	22081.68	66052.28	1240.834	0	41749.76	2.072509	-0.4793
7141.117	4238.892	54022.54	22305.02	73214.78	1246.945	0	44488.65	1.882197	-0.46397
3043.891	0	32456.97	39836.7	33208.36	18331.68	8144.729	24068.07	1.870916	-1.11517
3206.391	0	37509.75	42004.48	36469.2	22384.74	8473.062	26533.35	2.137809	-1.05292
3926.114	0	46119.2	53105.6	42290.31	24309.19	7867.229	33408.92	2.619799	-0.9414
5747.227	283.3336	48844.21	53207.82	46242.54	24669.19	7269.728	37561.7	3.004945	-0.80373
6845.839	1106.39	52017.26	50521.43	48697.54	19648.35	6240.838	39378.36	3.224943	-0.66835
8201.951	2470.002	55711.71	38828.36	52268.1	16048.35	5005.004	37933.36	3.249548	-0.59742
9402.785	3871.948	58009.21	29034.75	56959.77	13179.73	3635.836	40646.14	3.182839	-0.58372
8692.229	5047.782	59193.94	19546.4	61205.88	8130.284	2247.502	44721.7	3.081103	-0.57851
8903.896	5529.171	61501.99	16609.46	66329.78	6919.172	750.5562	48678.93	2.946145	-0.56444
8445.562	5469.171	62744.77	17797.51	72505.06	5556.393	0	52320.88	2.792915	-0.53943
8641.118	5435.282	64187	19117.24	80343.68	3090.836	0	56655.88	2.643176	-0.51119
3043.891	0	32456.97	39836.7	33208.36	18331.68	8144.729	24068.07	1.870916	-1.11517
3206.391	0	37509.75	42004.2	36469.2	22384.74	8473.062	26533.35	2.137674	-1.05305
3810.003	0	46055.59	53220.6	42279.76	24009.19	7867.229	33493.64	2.622219	-0.94735
5186.671	51.11115	51257.82	57441.99	47166.15	26573.91	7269.728	40201.42	3.02461	-0.87498
5782.227	353.6114	55947.27	58341.99	51116.15	26378.08	6240.838	45226.98	3.357604	-0.76014
6044.727	887.2229	60754.49	53971.43	55000.04	25233.63	5005.004	46773.65	3.533795	-0.68464
6444.727	2113.891	64994.22	43236.7	60364.77	21992.24	3635.836	44260.87	3.634248	-0.63276
8380.562	3533.614	67520.61	36400.03	66479.22	14908.35	2247.502	48018.37	3.673553	-0.59919
11433.34	4348.337	68437.83	27570.3	73263.67	7507.228	750.5562	52908.93	3.650251	-0.58042

12230.01	5557.782	69158.67	20659.18	79346.73	5596.949	0	57686.44	3.577758	-0.57019
12276.12	6303.338	71494.78	19265.85	86647.01	5862.782	0	63169.77	3.486103	-0.5531
3043.891	0	32456.97	39836.7	33208.36	18331.68	8144.729	24068.07	1.870916	-1.11517
3206.391	0	37509.75	42004.48	36469.2	22384.74	8473.062	26533.35	2.137552	-1.05317
3736.947	0	46134.2	53193.65	42396.98	24448.63	7867.229	33517.8	2.62302	-0.95176
5076.115	0	52752.82	57698.38	47921.15	29683.63	7269.728	40843.09	3.014606	-0.91873
4895.282	244.7224	58650.32	60561.72	52618.65	32125.86	6240.838	47216.7	3.394818	-0.8275
4881.671	447.7781	63993.66	59915.05	56920.05	31701.97	5005.004	50648.37	3.674516	-0.75301
5580.56	1561.39	69155.33	52582.54	62653.11	30912.8	3635.836	49144.48	3.89118	-0.70503
7414.45	2810.558	73558.95	43301.98	69062	29527.25	2247.502	49790.04	4.070099	-0.67132
9259.73	3662.781	75732.84	35413.08	76123.67	24261.13	750.5562	55097.82	4.202828	-0.63922
11259.73	5034.726	77219.51	27337.8	83875.9	16522.79	0	60473.66	4.272958	-0.59836
13450.29	6520.839	78401.73	22323.07	92553.96	9147.23	0	66616.16	4.280675	-0.57352
3043.891	0	32456.97	39836.7	33208.36	18331.68	8144.729	24068.07	1.870916	-1.11517
3206.391	0	37509.75	42004.2	36469.2	22384.74	8473.062	26533.35	2.137499	-1.05323
3697.781	0	46174.76	53297.26	42409.76	24570.58	7867.229	33517.8	2.623053	-0.95449
4490.281	0	53876.99	58480.88	48140.04	31065.3	7269.728	41195.87	3.010648	-0.95274
3947.781	148.3335	60285.33	61940.61	53316.99	34794.19	6240.838	48063.93	3.444984	-0.88809
3593.614	582.7782	66177	63063.94	58055.32	35313.08	5005.004	52414.76	3.843814	-0.82909
3746.67	915.2785	72733.11	58188.66	64732.55	37918.64	3635.836	52039.76	4.217579	-0.79107
5415.56	1620.001	77865.9	53309.76	71945.61	38260.59	2247.502	52122.82	4.579262	-0.74638
7643.339	2883.891	82848.4	57240.32	79387.01	37506.42	750.5562	57566.43	4.892227	-0.72265
10873.62	6001.116	87958.68	63363.94	88103.68	36701.97	0	63884.5	5.188424	-0.70114
12078.34	8383.618	92503.41	68263.39	97827.58	37581.42	0	70776.72	5.488135	-0.67303
3043.891	0	32455.86	39835.87	33208.36	18331.68	8144.729	24068.07	1.870916	-1.11517
3206.391	0	37509.75	42004.48	36469.2	22384.74	8473.062	26533.35	2.137271	-1.05348
3483.336	0	46305.04	52895.88	42489.48	25297.8	7867.229	33518.92	2.621972	-0.95996
3946.392	0	54548.38	58570.88	48318.65	32270.86	7269.728	41379.48	3.016565	-0.96481
3411.392	149.1668	61096.72	62748.94	53531.15	35879.47	6240.838	48473.93	3.469712	-0.91134
3177.78	585.2782	67383.11	64354.22	58375.6	37064.47	5005.004	53110.88	3.922371	-0.85972
3257.78	869.7229	74352.84	60428.1	65267	40495.03	3635.836	53238.38	4.394603	-0.82717
3838.336	1430.834	80741.18	55811.43	73488.95	44187.26	2247.502	52972.82	4.897461	-0.79114
5380.56	3290.558	86680.35	61531.16	81081.18	43771.7	750.5562	58662.55	5.421348	-0.77162
8679.174	6835.839	92354.52	69743.11	89548.13	41078.09	0	65752.83	5.982997	-0.74727
10266.95	8400.562	97734.8	76783.12	99807.3	42841.42	0	72969.78	6.560877	-0.71699
3071.919		35279.75	39557.2	34468	19847.21		23074.77	1.870916	-1.11517
3502.058		37264.2	42463.84	37604.42	20892.16		25451.69	2.133461	-1.05832
4376.67		44819.59	51740.46	45876.18	24281.96		32112.58	2.62038	-1.05672
5292.115		52027.96	56237.21	51622.24	27554.27		36183.42	3.144272	-1.00245
5787.477		47676.9	52596.88	49893.68	21246.74		30849.05	3.583005	-0.74743
6520.45		50103.54	50931.32	51445.18	22077.68		31632.41	3.654403	-0.65892
7079.006		52752.68	47797.73	52360.24	23263.82		31902.11	3.67028	-0.60667
7741.562		54299.74	42476.2	52339.99	24177.13		30929.19	3.671116	-0.5689
8327.146		56369.85	37699.97	52369.74	25481.44		30588.75	3.640354	-0.53959
8861.313		59243.16	33655.92	52726.71	27076.91		31140.66	3.588572	-0.51607
9404.146		63241.13	30782.3	53450.93	29041.16		32606	3.522411	-0.49848
3071.919		35279.75	39557.2	34468	19847.21		23074.77	1.870916	-1.11517

3502.058		37264.2	42463.84	37604.42	20892.16		25451.69	2.133461	-1.05832
4376.67		44819.59	51740.46	45876.18	24281.96		32112.58	2.624063	-1.05764
5293.976		52669.21	58051.44	52714.79	27905.22		37988.89	3.16509	-1.0252
5705.143		52872.13	58703.63	53846.4	24210.96		36487.92	3.63922	-0.85827
5874.727		55172.6	57557.41	54964.88	24809.41		36990.86	3.869095	-0.75849
6515.7		56265.82	52542.49	54840.57	24836.55		35695.06	4.0363	-0.65716
6789.117		59316.69	50846.01	55505.88	26291.83		36417.61	4.128543	-0.61656
7250.645		62322.55	47987.46	55979.71	27842.22		36715.08	4.204479	-0.59388
7804.923		65280.89	44866.65	56206.88	29444.94		36972.22	4.263437	-0.56796
8470.479		68181.47	41118.31	56142.32	31154.44		37216.75	4.293275	-0.54016
3071.919		35279.75	39557.2	34468	19847.21		23074.77	1.870916	-1.11517
3502.058		37264.2	42463.84	37604.42	20892.16		25451.69	2.133461	-1.05832
4376.67		44819.59	51740.46	45876.18	24281.96		32112.58	2.625554	-1.05774
5295.643		52721.88	58173.6	52794.29	27948.77		38133.34	3.17029	-1.03007
5784.449		55437.77	60203.6	55556.49	26378.58		38759.34	3.664934	-0.92088
5914.894		58832.13	59767.71	57419.21	27440.33		40078.12	3.988574	-0.86623
5889.394		63240.86	57883.96	59214.38	29644.5		41576.37	4.312689	-0.8375
5928.283		66394.55	56225.02	59911.71	30718.11		42198.76	4.660433	-0.77719
6123.977		69704.22	54062.35	60374.6	31987.97		42637.59	4.944131	-0.72588
6374.866		74349.25	52527.18	61409.24	34023.11		44080.23	5.183833	-0.6919
6837.45		79354.06	50493.98	62467.49	36556.58		45933.37	5.410145	-0.66614
3071.919		35279.75	39557.2	34468	19847.21		23074.77	1.870916	-1.11517
3501.225		37274.11	42567.4	37609.67	20955.74		25613.35	2.132032	-1.05977
4389.92		45014.45	52586.63	46178.43	24661.1		33383.89	2.617478	-1.08775
5359.699		53007.63	58899.3	53350.82	28228.8		39671.53	3.180898	-1.09001
6085.255		59226.52	61714.22	58106.77	30657.47		43833.31	3.758835	-1.07851
6498.477		64624.02	60672.72	61308.66	32673.03		46120.4	4.29286	-1.08097
6517.227		69276.81	58158.32	63412.75	34538.14		47609.7	4.839877	-1.06926
6520.005		74028.95	56349.66	65124.94	36746.61		49375.51	5.395268	-1.0574
6509.561		79029.29	54370.46	66698.86	39204.92		51120.46	5.961699	-1.04334
6496.7		84687.98	53227.38	68352.78	42125.76		53458.13	6.55243	-1.0171
6580.144		90537.04	51306.18	69938.06	45510.54		55908.07	7.165433	-0.98283
2701.973	0	48508.09	43841.42	33096.45	26956.14	8491.139	27346.69	2.135616	-1.05572
2767.583	92.31838	58485.16	51971.99	39927.69	31054.68	9495.258	32646.98	2.615401	-0.99488
1739.217	309.2333	57788.41	56000.58	43252.5	24030.18	11071.58	37062.67	3.044458	-0.76507
1221.922	622.6288	60423.4	58521.22	46658.46	21061.3	11745.65	41262.52	3.204259	-0.6486
735.3802	1041.755	61847.12	57587.43	48432.98	18060.01	12244.63	43342.77	3.255243	-0.60057
376.1912	1477.216	62852.19	54567.92	49104.11	15765.7	12604.08	43911.11	3.26705	-0.56657
155.1244	2087.28	64776.63	50560.52	49191.95	14303.45	12733.68	42665.37	3.236566	-0.53545
48.99802	2790.234	68041.28	46192.82	48694.64	13440.04	12654.5	39386.16	3.143147	-0.46992
11.98928	3572.18	73327.01	42562.55	47555.4	12533.02	12119.17	34825.29	2.944663	-0.42729
2.156813	4400.868	82492.57	40893.3	45843.79	11061.05	10825.39	29901.99	2.664341	-0.40271
2701.973	0	48508.09	43841.42	33096.45	26956.14	8491.139	27346.69	2.135616	-1.05572
2767.583	92.3178	58485.16	51971.99	39927.69	31054.68	9495.258	32646.98	2.609302	-1.00115
2198.401	285.6392	62143.71	58755.19	44521.3	28009.3	10680.94	38088.17	3.012552	-0.89439

1740.612	557.2728	65452.2	62911.4	48064.05	25711.47	11247.29	42912.55	3.316284	-0.76188
1220.632	909.3175	66612.28	63504.45	49765.74	22486.86	11662.09	45825.12	3.508918	-0.64169
757.8078	1247.838	66471.2	62023.48	50126.98	19080.38	11947.39	47729.97	3.599732	-0.5868
395.8454	1686.4	66658.96	58879.94	49717.71	16090.52	12026.73	48143.85	3.647063	-0.56231
169.3263	2178.072	67626.46	54459.86	48700.56	13966.79	11970.65	46484.75	3.64861	-0.53032
57.74609	2751.873	70197.89	50024.51	47258.48	12536.15	11594.09	43079.21	3.582218	-0.47848
14.94661	3334.38	75073.65	46435.93	45651.98	11394.6	10926.78	38365.65	3.425418	-0.43667
2701.973	0	48508.09	43841.42	33096.45	26956.14	8491.139	27346.69	2.135616	-1.05572
2767.583	92.3178	58485.16	51971.99	39927.69	31054.68	9495.258	32646.98	2.607601	-1.00299
2437.231	281.8351	64497.9	59891.61	45227.71	30042.5	10458.99	38548.67	3.015267	-0.93426
2058.022	535.0667	68636.04	64974.13	48933.48	28660.76	10967.67	43672.35	3.361464	-0.84463
1568.714	853.0959	70221.43	66840.17	50693.81	25799.07	11327.55	47032.85	3.640454	-0.72238
1085.383	1141.118	70036.52	66645.47	51024.29	22383.61	11559.2	49612.93	3.82707	-0.62644
653.7831	1499.085	69409.39	64323.06	50433.41	18871.89	11614.4	50926.99	3.935974	-0.57313
520.9109	1733.124	71116.33	64543.15	49567.31	17710.45	11158.75	52914.26	4.01949	-0.50505
392.7899	1919.49	72571.94	64344.19	47682.28	15973.46	10208.16	54252.31	4.06636	-0.48972
249.0487	2094.911	73405.53	62771.02	45509.21	13661.63	9396.814	54289.19	4.110232	-0.48657
2701.973	0	48508.09	43841.42	33096.45	26956.14	8491.139	27346.69	2.135616	-1.05572
2767.583	92.3178	58485.16	51971.99	39927.69	31054.68	9495.258	32646.98	2.606071	-1.00486
2783.683	282.7678	68334.51	61297.8	46611.49	33555.92	10061.38	39212.41	3.063226	-0.97452
2605.444	535.3603	74443.54	67706.25	50727.74	34069.81	10427.04	44781.75	3.522897	-0.92912
2316.082	837.0964	78250.32	71721.44	52785.83	33223.58	10582.59	48822.87	3.928056	-0.87019
1980.414	1056.849	80225.1	74828.05	53265.35	31433.53	10501.48	52562.09	4.287897	-0.82257
1601.953	1280.032	80912.62	76490.95	52655.87	28852.27	10245.25	55601.05	4.625374	-0.76462
1229.145	1479.183	80502.67	76535.56	51036.7	25727.1	9820.371	57595.26	4.934061	-0.66715
880.6666	1669.476	79656.21	75166.01	48734.43	22159.17	9176.197	58753.82	5.152049	-0.59421
587.1139	1828.339	78828.88	72778.54	46295.81	18620.29	8539.322	59210.43	5.293856	-0.54642
2650.637	0	43727.62	41495.3	30742.02	16189.01	7938.579	24985.54	1.870916	-1.11517
2701.973	0	48508.09	43841.42	33096.45	18465	8491.139	27346.69	2.134948	-1.05654
2797.068	93.89901	59727.31	52716.84	40357.18	22125.34	9405.006	32981.81	2.633581	-1.02161
2808.293	285.5336	68866.35	61720.32	46819.63	23838.41	9981.251	39358.56	3.182663	-0.99157
2656.13	541.7463	75306.91	68424.8	51026.87	24208.44	10313.45	45012.7	3.756655	-0.95201
2405.745	850.5726	79598.42	72762.38	53112.1	23592.62	10339.7	49157.57	4.286486	-0.89687
2129.215	1076.905	82279.09	76402.04	53700.7	22515.07	10182.43	53070.78	4.776581	-0.85874
1823.589	1305.609	83939.99	78857.25	53206.55	21041.22	9828.849	56385.71	5.25394	-0.81058
1545.66	1517.689	84846.11	80214.13	51650	19518.6	9182.252	58834.64	5.706287	-0.72685
1287.616	1714.148	85501	80844.71	49552.22	17873.03	8450.834	60721.14	6.083381	-0.67222
1061.125	1853.532	86370.08	81342.41	47393.56	16360.62	7754.914	62344.05	6.425488	-0.62586
3061.114	96.36119		35972.25		23627.8	9063.896	24141.69	1.870916	-1.11517
2925.002	108.889		37388.92		25311.13	9291.674	25991.69	2.138911	-1.05226
2966.669	132.5557		55222.27		22161.13	6388.894	37888.92	2.679534	-0.92699
2215.002	455.2781		77694.51		13511.12	2902.78	49527.82	3.096875	-0.74187
2054.168	4300.003		68416.72		7713.895	808.334	47361.15	3.242353	-0.58318
4136.114	9500.008		51694.49		4383.337	0	42583.37	3.161707	-0.47103
7194.45	11261.12		34444.47		2001.113	0	38277.81	2.91258	-0.44464

9922.23	12841.68	31555.58	1021.112	0	40722.25	2.629362	-0.43927
11294.45	15172.23	31555.58	589.7227	0	46027.81	2.371128	-0.43818
11597.23	17366.68	30527.8	468.0559	0	49416.71	2.131112	-0.4291
11852.79	18930.57	30527.8	383.6114	0	54277.82	1.890534	-0.41594
3061.114	96.36119	35972.25	23627.8	9063.896	24141.69	1.870916	-1.11517
2925.002	108.889	37388.92	25311.13	9291.674	25991.69	2.138941	-1.05221
2966.669	132.5557	55222.27	22161.13	6388.894	37888.92	2.678085	-0.92715
2908.336	213.9724	80888.95	14163.9	2902.78	52416.71	3.142186	-0.76715
2958.336	960.2785	88027.85	8544.451	808.334	57305.6	3.435167	-0.62639
2886.113	2571.669	85055.62	5450.004	0	60555.6	3.558382	-0.50837
4419.448	4313.892	69361.17	3011.114	0	57055.6	3.523943	-0.46815
7475.006	6377.783	53305.6	1959.724	0	52194.49	3.382893	-0.43928
10416.68	9902.786	44888.92	1574.168	0	53388.93	3.176578	-0.4211
12936.12	13519.46	39388.92	1493.89	0	54083.38	2.919882	-0.42299
14225.01	16419.46	37527.81	1365.834	0	58555.6	2.656269	-0.42371
3061.114	96.36119	35972.25	23627.8	9063.896	24141.69	1.870916	-1.11517
2925.002	108.889	37388.92	25311.13	9291.674	25991.69	2.138945	-1.05221
2966.669	132.5557	55222.27	22161.13	6388.894	37888.92	2.678056	-0.92803
3369.447	202.8613	76916.73	15963.9	2902.78	52388.93	3.172607	-0.78732
3483.336	651.6672	86583.4	10952.79	808.334	58777.82	3.558691	-0.65113
3400.003	1696.946	90861.18	7444.45	0	65583.39	3.778043	-0.53605
3386.114	3086.114	84000.07	4497.226	0	66972.28	3.875289	-0.4993
5105.56	4702.782	67611.17	2728.058	0	61805.61	3.903814	-0.46194
7866.673	7102.783	55944.49	2101.668	0	60861.16	3.832811	-0.43135
11361.12	10527.79	49583.37	2275.28	0	60833.38	3.660717	-0.4146
14350.01	13119.45	45250.04	2318.891	0	63083.38	3.431628	-0.40389
3061.114	96.36119	35972.25	23627.8	9063.896	24141.69	1.870916	-1.11517
2925.002	108.889	37388.92	25311.13	9291.674	25991.69	2.138944	-1.05221
2966.669	132.5557	55222.27	22161.13	6388.894	37888.92	2.678023	-0.92861
3402.781	195.8613	76805.62	16761.12	2902.78	52527.82	3.179688	-0.79923
3952.781	536.6671	87055.63	12816.68	808.334	59611.16	3.616277	-0.67046
4394.448	1255.279	95000.08	9097.23	0	68638.94	3.910007	-0.56386
4141.67	1883.335	95333.41	6358.338	0	74472.28	4.082963	-0.53123
4225.003	2471.113	84555.62	4280.559	0	73000.06	4.214922	-0.49825
5086.115	3644.447	78166.73	3450.003	0	75361.17	4.301837	-0.47013
6680.561	6116.672	72666.72	3222.225	0	76305.62	4.3241	-0.44489
7908.34	8075.006	70527.83	2938.891	0	81777.84	4.312506	-0.42656
3061.114	96.36119	35972.25	23627.8	9063.896	24141.69	1.870916	-1.11517
2925.002	108.889	37388.92	25311.13	9291.674	25991.69	2.138942	-1.05221
2966.669	132.5557	55222.27	22161.13	6388.894	37888.92	2.676709	-0.93024
3475.003	219.528	77222.28	17947.24	2902.78	53277.82	3.191565	-0.83427
4280.559	400.8337	89361.18	15847.23	808.334	61944.49	3.720313	-0.73787
5238.893	889.7229	100805.6	12877.79	0	73083.39	4.204516	-0.63106
5861.116	1421.946	107333.4	9577.785	0	82861.18	4.607925	-0.59371
5941.671	1675.001	102833.4	7141.672	0	85722.29	4.949741	-0.55274
5602.782	1893.335	99111.19	5591.671	0	90138.96	5.207266	-0.51623
5411.115	2822.224	91166.74	4366.67	0	89194.52	5.378522	-0.48478

5661.116	4197.226	84972.29	3711.114	0	93055.63	5.504735	-0.45672
3061.114	96.36119	35972.25	23627.8	9063.896	24141.69	1.870916	-1.11517
2925.002	108.889	37388.92	25311.13	9291.674	25991.69	2.137968	-1.05339
2930.558	134.7779	55666.71	22627.8	6388.894	38027.81	2.708892	-0.95575
3483.336	258.9447	78416.73	18841.68	2902.78	54000.04	3.336422	-0.87824
4491.67	491.9448	90750.07	17713.9	808.334	64138.94	4.053595	-0.81424
5541.671	929.4452	103361.2	15369.46	0	76916.73	4.837492	-0.72856
5950.005	1322.501	114861.2	12163.9	0	90416.74	5.640415	-0.70926
5891.671	1598.335	121027.9	9408.341	0	99083.41	6.479087	-0.68045
5675.005	1901.668	130472.3	7216.672	0	111639	7.307217	-0.64595
5725.005	2174.446	129472.3	5450.004	0	114666.8	8.052744	-0.60579
6075.005	2550.835	121555.7	4125.003	0	117000.1	8.69777	-0.55226

Radiative forcing (methane)	Radiative forcing (CO2)	Radiative forcing (f-gases)	Radiative forcing (Kyoto gases)	Radiative forcing (nitrous oxide)	GDP	Cropland	Forest	Pasture	Urban area
0.562305	1.689784	0.021105	2.34675	0.155711	5.74E+13	1.55E+09	3.73E+09	3.19E+09	67192000
0.588276	1.837859	0.031102	2.539069	0.167804	6.85E+13	1.58E+09	3.71E+09	3.19E+09	62963563
0.587912	2.126495	0.05629	2.87373	0.188953	1.02E+14	1.53E+09	3.72E+09	3.1E+09	77418556
0.507789	2.286914	0.060184	2.983996	0.203256	1.56E+14	1.52E+09	3.77E+09	3E+09	91698694
0.422359	2.297562	0.047899	2.918372	0.212165	2.23E+14	1.61E+09	3.81E+09	2.91E+09	1.05E+08
0.360978	2.233642	0.040867	2.802596	0.21973	2.91E+14	1.63E+09	3.91E+09	2.79E+09	1.16E+08
0.322647	2.14897	0.037774	2.688533	0.226153	3.56E+14	1.65E+09	4E+09	2.68E+09	1.19E+08
0.302464	2.056453	0.036675	2.583887	0.232355	4.19E+14	1.68E+09	4.08E+09	2.59E+09	1.21E+08
0.285537	1.948056	0.036537	2.467311	0.238767	4.75E+14	1.75E+09	4.14E+09	2.53E+09	1.21E+08
0.26893	1.817973	0.036705	2.329769	0.24532	5.25E+14	1.77E+09	4.2E+09	2.47E+09	1.19E+08
0.253994	1.662189	0.036653	2.167739	0.251879	5.65E+14	1.79E+09	4.23E+09	2.4E+09	1.16E+08
0.562305	1.689784	0.021105	2.34675	0.155711	5.74E+13	1.55E+09	3.73E+09	3.19E+09	67192000
0.588276	1.837859	0.031102	2.539069	0.167804	6.85E+13	1.58E+09	3.71E+09	3.19E+09	62963563
0.593697	2.157672	0.062164	2.915987	0.189224	1.02E+14	1.53E+09	3.72E+09	3.1E+09	77418556
0.530861	2.434354	0.084949	3.177712	0.205083	1.56E+14	1.48E+09	3.77E+09	3E+09	91698694
0.456194	2.624037	0.077491	3.306604	0.215457	2.23E+14	1.51E+09	3.85E+09	2.91E+09	1.05E+08
0.398372	2.722558	0.058852	3.344597	0.222913	2.91E+14	1.52E+09	3.97E+09	2.79E+09	1.16E+08
0.359934	2.748165	0.048949	3.333662	0.229083	3.56E+14	1.55E+09	4.06E+09	2.68E+09	1.19E+08
0.333714	2.721972	0.044354	3.286307	0.234898	4.19E+14	1.6E+09	4.12E+09	2.59E+09	1.21E+08
0.305963	2.642602	0.042279	3.18728	0.241008	4.75E+14	1.72E+09	4.14E+09	2.53E+09	1.21E+08
0.283203	2.514044	0.0413	3.045488	0.248186	5.25E+14	1.82E+09	4.16E+09	2.47E+09	1.19E+08
0.267574	2.38049	0.040553	2.905152	0.255495	5.65E+14	1.77E+09	4.22E+09	2.4E+09	1.16E+08
0.562305	1.689784	0.021105	2.34675	0.155711	5.74E+13	1.55E+09	3.73E+09	3.19E+09	67192000
0.588276	1.837859	0.031102	2.539069	0.167804	6.85E+13	1.58E+09	3.71E+09	3.19E+09	62963563
0.614046	2.165302	0.064886	2.944814	0.190343	1.02E+14	1.54E+09	3.71E+09	3.12E+09	77418556
0.5851	2.480179	0.104262	3.293846	0.20981	1.56E+14	1.5E+09	3.75E+09	3.04E+09	91698694
0.518965	2.759221	0.130879	3.557826	0.224548	2.23E+14	1.53E+09	3.83E+09	2.95E+09	1.05E+08
0.46013	2.986978	0.138963	3.75372	0.234802	2.91E+14	1.54E+09	3.95E+09	2.83E+09	1.16E+08
0.417503	3.15954	0.130103	3.888342	0.242097	3.56E+14	1.54E+09	4.06E+09	2.71E+09	1.19E+08
0.377451	3.268606	0.117908	3.956422	0.247491	4.19E+14	1.56E+09	4.16E+09	2.63E+09	1.21E+08
0.337522	3.293187	0.098625	3.93196	0.251814	4.75E+14	1.6E+09	4.24E+09	2.56E+09	1.21E+08
0.303393	3.224016	0.076575	3.816512	0.256723	5.25E+14	1.74E+09	4.22E+09	2.5E+09	1.19E+08
0.281587	3.098069	0.064914	3.666768	0.263206	5.65E+14	1.84E+09	4.18E+09	2.43E+09	1.16E+08
0.562305	1.689784	0.021105	2.34675	0.155711	5.74E+13	1.55E+09	3.73E+09	3.19E+09	67192000
0.588276	1.837859	0.031102	2.539069	0.167804	6.85E+13	1.58E+09	3.71E+09	3.19E+09	62963563
0.616108	2.166663	0.065143	2.948266	0.190418	1.02E+14	1.54E+09	3.7E+09	3.13E+09	77418556
0.600012	2.491989	0.107422	3.322438	0.210713	1.56E+14	1.51E+09	3.74E+09	3.06E+09	91698694
0.558577	2.800595	0.150954	3.656641	0.228122	2.23E+14	1.54E+09	3.8E+09	2.98E+09	1.05E+08
0.517918	3.081786	0.193118	3.960117	0.242929	2.91E+14	1.55E+09	3.87E+09	2.86E+09	1.16E+08

0.482021	3.330038	0.227216	4.22383	0.254919	3.56E+14	1.55E+09	3.94E+09	2.74E+09	1.19E+08
0.441072	3.536311	0.241699	4.418094	0.263369	4.19E+14	1.56E+09	4.01E+09	2.66E+09	1.21E+08
0.395604	3.681662	0.225876	4.514041	0.268592	4.75E+14	1.61E+09	4.06E+09	2.59E+09	1.21E+08
0.351238	3.76573	0.206082	4.543719	0.271865	5.25E+14	1.63E+09	4.11E+09	2.52E+09	1.19E+08
0.31245	3.801884	0.189608	4.532638	0.274216	5.65E+14	1.62E+09	4.16E+09	2.46E+09	1.16E+08
0.562305	1.689784	0.021105	2.34675	0.155711	5.74E+13	1.55E+09	3.73E+09	3.19E+09	67192000
0.588276	1.837859	0.031102	2.539069	0.167804	6.85E+13	1.58E+09	3.71E+09	3.19E+09	62963563
0.620427	2.167961	0.06525	2.953577	0.190641	1.02E+14	1.55E+09	3.7E+09	3.14E+09	77418556
0.633706	2.504503	0.108899	3.366587	0.212134	1.56E+14	1.52E+09	3.7E+09	3.08E+09	91698694
0.640193	2.835057	0.159799	3.773374	0.231935	2.23E+14	1.55E+09	3.73E+09	3.01E+09	1.05E+08
0.631824	3.141208	0.212557	4.14256	0.249349	2.91E+14	1.57E+09	3.78E+09	2.89E+09	1.16E+08
0.61045	3.421694	0.257734	4.464824	0.26418	3.56E+14	1.57E+09	3.84E+09	2.78E+09	1.19E+08
0.581716	3.678986	0.297662	4.750294	0.276938	4.19E+14	1.58E+09	3.89E+09	2.69E+09	1.21E+08
0.542534	3.894973	0.334758	4.98104	0.288024	4.75E+14	1.61E+09	3.92E+09	2.62E+09	1.21E+08
0.49836	4.067145	0.365317	5.155511	0.297451	5.25E+14	1.63E+09	3.95E+09	2.55E+09	1.19E+08
0.459471	4.210662	0.383124	5.291111	0.30491	5.65E+14	1.6E+09	4E+09	2.49E+09	1.16E+08
0.562305	1.689784	0.021105	2.34675	0.155711	5.65E+13	1.54E+09	3.92E+09	3.43E+09	
0.588276	1.837859	0.031102	2.539069	0.167804	6.75E+13	1.55E+09	3.89E+09	3.42E+09	
0.61707	2.151473	0.06133	2.930644	0.190979	1.01E+14	1.61E+09	3.91E+09	3.38E+09	
0.58715	2.351585	0.077088	3.14249	0.212475	1.41E+14	1.68E+09	3.96E+09	3.36E+09	
0.509574	2.396929	0.075699	3.137563	0.22977	1.81E+14	1.73E+09	4.06E+09	3.16E+09	
0.435621	2.364166	0.076608	3.053658	0.240821	2.23E+14	1.76E+09	4.19E+09	2.95E+09	
0.380312	2.285698	0.079394	2.936336	0.246385	2.69E+14	1.8E+09	4.32E+09	2.75E+09	
0.338259	2.169025	0.082533	2.788741	0.248219	3.21E+14	1.87E+09	4.42E+09	2.58E+09	
0.301909	2.020294	0.084975	2.610428	0.247229	3.78E+14	1.91E+09	4.49E+09	2.44E+09	
0.271782	1.858256	0.086585	2.421552	0.244504	4.38E+14	1.93E+09	4.55E+09	2.33E+09	
0.249517	1.701561	0.087789	2.242835	0.240289	5.05E+14	1.94E+09	4.61E+09	2.24E+09	
0.562305	1.689784	0.021105	2.34675	0.155711	5.65E+13	1.54E+09	3.92E+09	3.43E+09	
0.588276	1.837859	0.031102	2.539069	0.167804	6.75E+13	1.55E+09	3.89E+09	3.42E+09	
0.617437	2.149903	0.061264	2.929337	0.190994	1.01E+14	1.62E+09	3.9E+09	3.38E+09	
0.60655	2.413017	0.078293	3.222621	0.213422	1.42E+14	1.68E+09	3.92E+09	3.39E+09	
0.559263	2.595962	0.080345	3.387617	0.233756	1.84E+14	1.73E+09	3.96E+09	3.36E+09	
0.496306	2.693107	0.084704	3.451632	0.249976	2.29E+14	1.78E+09	4.05E+09	3.28E+09	
0.449361	2.713744	0.089193	3.44877	0.262045	2.77E+14	1.82E+09	4.15E+09	3.12E+09	
0.420164	2.673226	0.092784	3.395633	0.270751	3.31E+14	1.89E+09	4.24E+09	2.98E+09	
0.395895	2.57974	0.096069	3.289546	0.275577	3.9E+14	1.96E+09	4.33E+09	2.85E+09	
0.366439	2.461945	0.098798	3.150762	0.277001	4.54E+14	2.01E+09	4.41E+09	2.73E+09	
0.33553	2.341671	0.101286	3.005621	0.27603	5.25E+14	2.04E+09	4.48E+09	2.61E+09	
0.562305	1.689784	0.021105	2.34675	0.155711	5.65E+13	1.54E+09	3.92E+09	3.43E+09	
0.588276	1.837859	0.031102	2.539069	0.167804	6.75E+13	1.55E+09	3.89E+09	3.42E+09	
0.618688	2.156237	0.06126	2.936828	0.191089	1.01E+14	1.62E+09	3.88E+09	3.4E+09	
0.621345	2.467845	0.083669	3.296106	0.214084	1.43E+14	1.66E+09	3.88E+09	3.43E+09	
0.592793	2.749819	0.090979	3.582878	0.235924	1.85E+14	1.72E+09	3.88E+09	3.43E+09	
0.537515	2.97831	0.094226	3.786408	0.254871	2.3E+14	1.77E+09	3.93E+09	3.39E+09	
0.488544	3.133864	0.09806	3.919573	0.270427	2.79E+14	1.82E+09	4.01E+09	3.33E+09	
0.459203	3.206403	0.103224	3.984654	0.282841	3.34E+14	1.87E+09	4.09E+09	3.26E+09	
0.441564	3.211701	0.106661	3.986807	0.291311	3.94E+14	1.94E+09	4.16E+09	3.15E+09	

0.425481	3.168402	0.108445	3.936196	0.29594	4.6E+14	1.99E+09	4.25E+09	3.02E+09	
0.405663	3.097801	0.110579	3.852951	0.298074	5.32E+14	2.02E+09	4.33E+09	2.9E+09	
0.562305	1.689784	0.021105	2.34675	0.155711	5.65E+13	1.54E+09	3.92E+09	3.43E+09	
0.588276	1.837859	0.031102	2.539069	0.167804	6.75E+13	1.55E+09	3.89E+09	3.42E+09	
0.619873	2.159908	0.061273	2.94157	0.191135	1.01E+14	1.62E+09	3.88E+09	3.41E+09	
0.627489	2.487764	0.087113	3.324946	0.21432	1.43E+14	1.66E+09	3.86E+09	3.44E+09	
0.614632	2.812848	0.098791	3.673209	0.236786	1.86E+14	1.71E+09	3.85E+09	3.45E+09	
0.578009	3.118515	0.101803	3.970963	0.257099	2.31E+14	1.76E+09	3.87E+09	3.44E+09	
0.532436	3.384324	0.103702	4.217531	0.274837	2.8E+14	1.8E+09	3.93E+09	3.42E+09	
0.499299	3.598281	0.108015	4.422663	0.289969	3.36E+14	1.85E+09	4E+09	3.37E+09	
0.477175	3.749493	0.112576	4.570861	0.301271	3.96E+14	1.91E+09	4.06E+09	3.31E+09	
0.46059	3.82146	0.116856	4.640268	0.308584	4.63E+14	1.95E+09	4.12E+09	3.24E+09	
0.449891	3.832534	0.119682	4.649403	0.312947	5.35E+14	1.98E+09	4.2E+09	3.14E+09	
0.562305	1.689784	0.021105	2.34675	0.155711	5.65E+13	1.54E+09	3.92E+09	3.43E+09	
0.588276	1.837859	0.031102	2.539069	0.167804	6.75E+13	1.55E+09	3.89E+09	3.42E+09	
0.621315	2.160564	0.061275	2.94351	0.191189	1.01E+14	1.62E+09	3.87E+09	3.41E+09	
0.636997	2.498892	0.091407	3.348699	0.214542	1.43E+14	1.66E+09	3.86E+09	3.45E+09	
0.6457	2.858792	0.119426	3.766984	0.237486	1.86E+14	1.7E+09	3.84E+09	3.49E+09	
0.637477	3.234801	0.148527	4.186449	0.258855	2.31E+14	1.75E+09	3.85E+09	3.5E+09	
0.614447	3.61311	0.173135	4.589233	0.278363	2.8E+14	1.81E+09	3.86E+09	3.5E+09	
0.590103	3.979853	0.183224	4.963085	0.296147	3.37E+14	1.85E+09	3.88E+09	3.5E+09	
0.56345	4.332558	0.17176	5.296761	0.311316	3.98E+14	1.88E+09	3.91E+09	3.49E+09	
0.535615	4.67138	0.157098	5.609974	0.324115	4.65E+14	1.9E+09	3.96E+09	3.47E+09	
0.507884	4.994292	0.151042	5.91444	0.335382	5.38E+14	1.91E+09	4.03E+09	3.43E+09	
0.562305	1.689784	0.021105	2.34675	0.155711	5.65E+13	1.54E+09	3.92E+09	3.43E+09	
0.588276	1.837859	0.031102	2.539069	0.167804	6.75E+13	1.55E+09	3.89E+09	3.42E+09	
0.624748	2.159722	0.061417	2.945842	0.191292	1.01E+14	1.62E+09	3.87E+09	3.42E+09	
0.647046	2.500869	0.093018	3.361601	0.215286	1.43E+14	1.66E+09	3.86E+09	3.45E+09	
0.664906	2.875136	0.122854	3.805414	0.239765	1.86E+14	1.71E+09	3.84E+09	3.5E+09	
0.676128	3.280468	0.156046	4.277484	0.263741	2.31E+14	1.75E+09	3.83E+09	3.53E+09	
0.685959	3.706119	0.192871	4.771584	0.286982	2.81E+14	1.81E+09	3.84E+09	3.56E+09	
0.695531	4.143406	0.23523	5.28189	0.30948	3.37E+14	1.86E+09	3.84E+09	3.58E+09	
0.699882	4.607236	0.283043	5.818905	0.331141	3.98E+14	1.89E+09	3.85E+09	3.6E+09	
0.698119	5.1021	0.334059	6.384739	0.352599	4.66E+14	1.92E+09	3.85E+09	3.62E+09	
0.688933	5.608091	0.386994	6.957501	0.374267	5.39E+14	1.94E+09	3.88E+09	3.63E+09	
0.562305	1.689784	0.021105	2.34675	0.155711	5.47E+13	1.53E+09	3.9E+09	3.38E+09	61494300
0.588276	1.837859	0.031102	2.539069	0.167804	6.48E+13	1.57E+09	3.85E+09	3.47E+09	61494300
0.645306	2.19016	0.055151	2.988596	0.192341	9.74E+13	1.66E+09	3.75E+09	3.61E+09	61494300
0.704065	2.564968	0.067003	3.45152	0.218497	1.3E+14	1.74E+09	3.68E+09	3.67E+09	61494300
0.693543	2.838265	0.066193	3.736247	0.23971	1.5E+14	1.81E+09	3.72E+09	3.69E+09	61494300
0.618935	2.980298	0.058681	3.82201	0.254578	1.66E+14	1.93E+09	3.71E+09	3.68E+09	61494300
0.568626	3.057819	0.048947	3.861946	0.269637	1.8E+14	2.05E+09	3.66E+09	3.67E+09	61494300
0.548939	3.082726	0.043026	3.878947	0.284447	1.95E+14	2.16E+09	3.65E+09	3.68E+09	61494300
0.537888	3.060543	0.039115	3.857332	0.298355	2.09E+14	2.23E+09	3.68E+09	3.68E+09	61494300
0.53274	3.006709	0.036354	3.809533	0.311542	2.25E+14	2.27E+09	3.71E+09	3.66E+09	61494300
0.531503	2.932619	0.034317	3.744965	0.324156	2.42E+14	2.3E+09	3.75E+09	3.63E+09	61494300
0.562305	1.689784	0.021105	2.34675	0.155711	5.47E+13	1.53E+09	3.9E+09	3.38E+09	61494300

0.588276	1.837859	0.031102	2.539069	0.167804	6.48E+13	1.57E+09	3.85E+09	3.47E+09	61494300
0.645296	2.190167	0.059735	2.993178	0.192341	9.74E+13	1.66E+09	3.75E+09	3.61E+09	61494300
0.708194	2.578311	0.087233	3.489152	0.219037	1.3E+14	1.74E+09	3.67E+09	3.67E+09	61494300
0.709338	2.919511	0.098862	3.866522	0.242602	1.53E+14	1.81E+09	3.65E+09	3.68E+09	61494300
0.658075	3.176725	0.092152	4.091898	0.261188	1.7E+14	1.94E+09	3.61E+09	3.68E+09	61494300
0.621991	3.346415	0.084662	4.241348	0.279211	1.83E+14	2.1E+09	3.54E+09	3.68E+09	61494300
0.607819	3.442875	0.08233	4.34081	0.296633	1.99E+14	2.18E+09	3.52E+09	3.69E+09	61494300
0.609061	3.512092	0.080073	4.426237	0.314041	2.16E+14	2.25E+09	3.5E+09	3.7E+09	61494300
0.613461	3.558569	0.071974	4.485369	0.331042	2.33E+14	2.32E+09	3.51E+09	3.69E+09	61494300
0.613692	3.5745	0.065749	4.511286	0.347056	2.51E+14	2.37E+09	3.54E+09	3.67E+09	61494300
0.562305	1.689784	0.021105	2.34675	0.155711	5.47E+13	1.53E+09	3.9E+09	3.38E+09	61494300
0.588276	1.837859	0.031102	2.539069	0.167804	6.48E+13	1.57E+09	3.85E+09	3.47E+09	61494300
0.645293	2.190169	0.061331	2.994774	0.192341	9.74E+13	1.66E+09	3.75E+09	3.61E+09	61494300
0.708719	2.579624	0.094649	3.498398	0.219105	1.3E+14	1.74E+09	3.67E+09	3.67E+09	61494300
0.724567	2.949284	0.120945	3.932879	0.244117	1.53E+14	1.82E+09	3.63E+09	3.68E+09	61494300
0.697358	3.281723	0.137246	4.280054	0.265752	1.72E+14	1.94E+09	3.57E+09	3.68E+09	61494300
0.691516	3.601867	0.150688	4.630892	0.287988	1.87E+14	2.08E+09	3.47E+09	3.69E+09	61494300
0.702423	3.89489	0.157224	4.962386	0.310621	2.04E+14	2.21E+09	3.39E+09	3.7E+09	61494300
0.711822	4.136157	0.15372	5.230225	0.332683	2.21E+14	2.31E+09	3.35E+09	3.71E+09	61494300
0.724909	4.339095	0.147349	5.459772	0.354503	2.4E+14	2.39E+09	3.31E+09	3.71E+09	61494300
0.74118	4.524208	0.143976	5.677172	0.376291	2.62E+14	2.47E+09	3.27E+09	3.7E+09	61494300
0.562305	1.689784	0.021105	2.34675	0.155711	5.47E+13	1.53E+09	3.9E+09	3.38E+09	61494300
0.588276	1.837859	0.031102	2.539069	0.167804	6.48E+13	1.57E+09	3.85E+09	3.47E+09	61494300
0.649781	2.200611	0.061429	3.009734	0.192934	9.74E+13	1.66E+09	3.75E+09	3.61E+09	61494300
0.722132	2.620565	0.096203	3.554564	0.22134	1.3E+14	1.74E+09	3.67E+09	3.67E+09	61494300
0.791048	3.066355	0.129301	4.122755	0.251888	1.55E+14	1.81E+09	3.62E+09	3.67E+09	61494300
0.852488	3.525137	0.160367	4.696629	0.283541	1.74E+14	1.89E+09	3.57E+09	3.68E+09	61494300
0.908723	3.989162	0.187713	5.268413	0.316027	1.9E+14	1.98E+09	3.51E+09	3.68E+09	61494300
0.961772	4.456451	0.21072	5.837237	0.349348	2.08E+14	2.07E+09	3.46E+09	3.7E+09	61494300
1.013292	4.928548	0.231493	6.407978	0.383323	2.27E+14	2.15E+09	3.41E+09	3.71E+09	61494300
1.063375	5.408881	0.251077	6.984998	0.41776	2.47E+14	2.21E+09	3.37E+09	3.71E+09	61494300
1.112223	5.901405	0.270318	7.573102	0.45249	2.7E+14	2.28E+09	3.33E+09	3.7E+09	61494300

0.588276	1.837859	0.031102	2.539069	0.167804	6.69E+13	1.5E+09	4.09E+09	3.25E+09	61326101
0.634235	2.166646	0.04695	2.946263	0.191165	9.98E+13	1.53E+09	4.08E+09	3.29E+09	61326101
0.642523	2.392256	0.049387	3.20342	0.213207	1.42E+14	1.62E+09	4.24E+09	3.22E+09	61326101
0.636712	2.480844	0.046121	3.305027	0.234446	1.82E+14	1.77E+09	4.31E+09	3.19E+09	61326101
0.645415	2.5265	0.040973	3.375443	0.256934	2.19E+14	1.95E+09	4.31E+09	3.19E+09	61326101
0.65195	2.539541	0.036665	3.413246	0.28043	2.52E+14	2.22E+09	4.19E+09	3.18E+09	61326101
0.652158	2.505161	0.035044	3.401676	0.304684	2.82E+14	2.48E+09	4.06E+09	3.17E+09	61326101
0.640923	2.393365	0.034808	3.304191	0.328812	3.07E+14	2.69E+09	3.98E+09	3.12E+09	61326101
0.621144	2.197098	0.035395	3.114242	0.351412	3.3E+14	2.83E+09	3.94E+09	3.06E+09	61326101
0.600635	1.928294	0.036579	2.849794	0.372076	3.52E+14	2.94E+09	3.92E+09	3E+09	61326101

0.588276	1.837859	0.031102	2.539069	0.167804	6.69E+13	1.5E+09	4.09E+09	3.25E+09	61326101
0.634235	2.166646	0.04695	2.946263	0.191165	9.98E+13	1.53E+09	4.08E+09	3.29E+09	61326101
0.650287	2.457222	0.049376	3.275549	0.213759	1.41E+14	1.57E+09	4.19E+09	3.28E+09	61326101

0.654695	2.662389	0.046109	3.503371	0.235922	1.82E+14	1.64E+09	4.28E+09	3.27E+09	61326101
0.665937	2.788353	0.040958	3.656625	0.258777	2.19E+14	1.72E+09	4.34E+09	3.29E+09	61326101
0.67359	2.85889	0.036683	3.752758	0.28212	2.52E+14	1.88E+09	4.29E+09	3.31E+09	61326101
0.678121	2.898618	0.035066	3.818522	0.30591	2.82E+14	2.08E+09	4.2E+09	3.31E+09	61326101
0.674256	2.893042	0.034803	3.833601	0.330125	3.07E+14	2.35E+09	4.09E+09	3.27E+09	61326101
0.660414	2.813067	0.03531	3.766428	0.354222	3.3E+14	2.57E+09	4E+09	3.2E+09	61326101
0.640362	2.653878	0.036318	3.613899	0.376975	3.52E+14	2.74E+09	3.96E+09	3.12E+09	61326101
0.588276	1.837859	0.031102	2.539069	0.167804	6.69E+13	1.5E+09	4.09E+09	3.25E+09	61326101
0.634235	2.166646	0.04695	2.946263	0.191165	9.98E+13	1.53E+09	4.08E+09	3.29E+09	61326101
0.656481	2.48289	0.049463	3.307126	0.214299	1.41E+14	1.57E+09	4.15E+09	3.3E+09	61326101
0.669348	2.75507	0.046301	3.610373	0.237556	1.82E+14	1.61E+09	4.22E+09	3.31E+09	61326101
0.684668	2.960569	0.041178	3.847518	0.26126	2.19E+14	1.66E+09	4.3E+09	3.33E+09	61326101
0.692696	3.091451	0.036928	4.00475	0.285015	2.52E+14	1.75E+09	4.29E+09	3.36E+09	61326101
0.695985	3.170621	0.035329	4.10881	0.308699	2.82E+14	1.87E+09	4.26E+09	3.39E+09	61326101
0.696918	3.215871	0.035032	4.178512	0.332653	3.07E+14	1.91E+09	4.22E+09	3.43E+09	61326101
0.699614	3.251154	0.035451	4.240631	0.356771	3.3E+14	1.93E+09	4.21E+09	3.45E+09	61326101
0.703168	3.286504	0.036296	4.303723	0.380637	3.52E+14	2E+09	4.19E+09	3.44E+09	61326101
0.588276	1.837859	0.031102	2.539069	0.167804	6.69E+13	1.5E+09	4.09E+09	3.25E+09	61326101
0.634235	2.166646	0.04695	2.946263	0.191165	9.98E+13	1.53E+09	4.08E+09	3.29E+09	61326101
0.682513	2.521626	0.050001	3.371352	0.217052	1.41E+14	1.58E+09	4.07E+09	3.34E+09	61326101
0.73123	2.893426	0.047493	3.811703	0.246572	1.82E+14	1.63E+09	4.06E+09	3.39E+09	61326101
0.76445	3.250025	0.042702	4.221762	0.276499	2.19E+14	1.65E+09	4.07E+09	3.44E+09	61326101
0.782969	3.577964	0.038865	4.590759	0.305606	2.52E+14	1.69E+09	4.07E+09	3.49E+09	61326101
0.791254	3.872664	0.037667	4.918909	0.333192	2.82E+14	1.7E+09	4.08E+09	3.54E+09	61326101
0.788514	4.1144	0.037705	5.184012	0.358857	3.07E+14	1.71E+09	4.11E+09	3.57E+09	61326101
0.778293	4.290926	0.038337	5.376374	0.382773	3.3E+14	1.71E+09	4.16E+09	3.57E+09	61326101
0.766302	4.410304	0.039267	5.509168	0.405481	3.52E+14	1.72E+09	4.21E+09	3.56E+09	61326101
0.562305	1.689784	0.021105	2.34675	0.155711	5.67E+13	1.52E+09	4.08E+09	3.31E+09	55230223
0.588276	1.837859	0.031102	2.539069	0.167804	6.69E+13	1.5E+09	4.09E+09	3.25E+09	61326101
0.64437	2.176313	0.06181	2.980581	0.192313	9.98E+13	1.53E+09	4.08E+09	3.29E+09	61326101
0.714351	2.556578	0.10475	3.490897	0.219748	1.41E+14	1.58E+09	4.06E+09	3.34E+09	61326101
0.787469	2.968715	0.150745	4.041817	0.250196	1.82E+14	1.64E+09	4.02E+09	3.39E+09	61326101
0.842614	3.380591	0.190665	4.573054	0.282631	2.19E+14	1.68E+09	3.99E+09	3.46E+09	61326101
0.880003	3.780524	0.225359	5.07309	0.316172	2.52E+14	1.73E+09	3.95E+09	3.52E+09	61326101
0.908121	4.162736	0.25527	5.543113	0.350109	2.82E+14	1.75E+09	3.92E+09	3.59E+09	61326101
0.921773	4.508214	0.280093	5.959064	0.384125	3.07E+14	1.77E+09	3.9E+09	3.64E+09	61326101
0.923408	4.816006	0.299727	6.321598	0.417839	3.3E+14	1.77E+09	3.89E+09	3.67E+09	61326101
0.920803	5.100397	0.314992	6.652367	0.451172	3.52E+14	1.76E+09	3.89E+09	3.69E+09	61326101
0.562305	1.689784	0.021105	2.34675	0.155711	5.67E+13	1.47E+09	4.19E+09	3.12E+09	1.33E+08
0.588276	1.837859	0.031102	2.539069	0.167804	6.76E+13	1.52E+09	4.17E+09	3.09E+09	1.33E+08
0.627201	2.162293	0.061349	2.950228	0.191084	1.02E+14	1.62E+09	4.16E+09	2.95E+09	1.33E+08
0.592344	2.467259	0.071906	3.256308	0.21137	1.63E+14	1.68E+09	4.16E+09	2.89E+09	1.33E+08
0.501608	2.654811	0.057214	3.369834	0.22944	2.47E+14	1.88E+09	4.16E+09	2.66E+09	1.33E+08
0.434913	2.641123	0.045271	3.309223	0.251369	3.38E+14	2.21E+09	4.17E+09	2.31E+09	1.33E+08
0.391864	2.460249	0.039636	3.109441	0.274838	4.41E+14	2.29E+09	4.17E+09	2.22E+09	1.33E+08

0.366445	2.221032	0.037256	2.865983	0.294672	5.6E+14	2.35E+09	4.17E+09	2.15E+09	1.33E+08
0.348357	1.992062	0.03648	2.637918	0.311793	6.87E+14	2.38E+09	4.17E+09	2.09E+09	1.33E+08
0.329917	1.771622	0.036292	2.416643	0.326887	8.19E+14	2.37E+09	4.18E+09	2.01E+09	1.33E+08
0.307836	1.551348	0.036189	2.189296	0.338768	9.6E+14	2.27E+09	4.18E+09	2.01E+09	1.33E+08
0.562305	1.689784	0.021105	2.34675	0.155711	5.67E+13	1.47E+09	4.19E+09	3.12E+09	1.33E+08
0.588276	1.837859	0.031102	2.539069	0.167804	6.76E+13	1.52E+09	4.15E+09	3.08E+09	1.33E+08
0.627376	2.161606	0.061344	2.949634	0.191032	1.02E+14	1.63E+09	4.14E+09	2.99E+09	1.33E+08
0.617671	2.497531	0.071894	3.309226	0.212427	1.65E+14	1.68E+09	4.14E+09	2.93E+09	1.33E+08
0.557367	2.800359	0.05732	3.563816	0.230199	2.55E+14	1.77E+09	4.14E+09	2.81E+09	1.33E+08
0.494354	2.987606	0.045232	3.701127	0.246109	3.52E+14	2E+09	4.14E+09	2.59E+09	1.33E+08
0.450187	3.017384	0.039547	3.705502	0.264079	4.56E+14	2.23E+09	4.14E+09	2.34E+09	1.33E+08
0.415291	2.917297	0.037128	3.592801	0.283663	5.77E+14	2.3E+09	4.14E+09	2.27E+09	1.33E+08
0.381109	2.749864	0.036332	3.413017	0.301282	7.03E+14	2.34E+09	4.14E+09	2.23E+09	1.33E+08
0.345932	2.545172	0.036133	3.19333	0.316512	8.34E+14	2.37E+09	4.15E+09	2.2E+09	1.33E+08
0.315616	2.323783	0.036013	2.959306	0.329877	9.75E+14	2.39E+09	4.15E+09	2.18E+09	1.33E+08
0.562305	1.689784	0.021105	2.34675	0.155711	5.67E+13	1.47E+09	4.19E+09	3.12E+09	1.33E+08
0.588276	1.837859	0.031102	2.539069	0.167804	6.76E+13	1.52E+09	4.15E+09	3.08E+09	1.33E+08
0.627381	2.161538	0.062255	2.950481	0.191032	1.02E+14	1.63E+09	4.14E+09	2.99E+09	1.33E+08
0.638325	2.505079	0.087044	3.350013	0.2129	1.65E+14	1.67E+09	4.14E+09	2.94E+09	1.33E+08
0.60739	2.845634	0.089641	3.68588	0.232	2.56E+14	1.74E+09	4.14E+09	2.86E+09	1.33E+08
0.552155	3.125341	0.073499	3.916871	0.246539	3.55E+14	1.78E+09	4.14E+09	2.82E+09	1.33E+08
0.500423	3.316805	0.055815	4.057759	0.257783	4.63E+14	1.92E+09	4.14E+09	2.67E+09	1.33E+08
0.459066	3.401235	0.047303	4.110856	0.270249	5.84E+14	2.06E+09	4.14E+09	2.53E+09	1.33E+08
0.419591	3.373447	0.043223	4.059331	0.284278	7.13E+14	2.19E+09	4.14E+09	2.37E+09	1.33E+08
0.377866	3.249438	0.041136	3.912185	0.298839	8.47E+14	2.22E+09	4.15E+09	2.33E+09	1.33E+08
0.336914	3.068758	0.039872	3.70842	0.311975	9.87E+14	2.23E+09	4.15E+09	2.32E+09	1.33E+08
0.562305	1.689784	0.021105	2.34675	0.155711	5.67E+13	1.47E+09	4.19E+09	3.12E+09	1.33E+08
0.588276	1.837859	0.031102	2.539069	0.167804	6.76E+13	1.52E+09	4.15E+09	3.08E+09	1.33E+08
0.627381	2.161493	0.062795	2.950976	0.191032	1.02E+14	1.63E+09	4.14E+09	2.99E+09	1.33E+08
0.639405	2.507651	0.100062	3.366648	0.213023	1.65E+14	1.67E+09	4.14E+09	2.94E+09	1.33E+08
0.621986	2.864143	0.12411	3.752031	0.232722	2.56E+14	1.74E+09	4.14E+09	2.87E+09	1.33E+08
0.57929	3.186294	0.128383	4.058074	0.248759	3.57E+14	1.77E+09	4.14E+09	2.83E+09	1.33E+08
0.526813	3.446533	0.119182	4.276482	0.260894	4.67E+14	1.82E+09	4.14E+09	2.77E+09	1.33E+08
0.487433	3.632592	0.1146	4.435096	0.271628	5.9E+14	1.89E+09	4.14E+09	2.7E+09	1.33E+08
0.455517	3.759218	0.109984	4.540051	0.281808	7.23E+14	1.92E+09	4.14E+09	2.66E+09	1.33E+08
0.420285	3.839908	0.089942	4.57938	0.290555	8.63E+14	1.93E+09	4.15E+09	2.61E+09	1.33E+08
0.379409	3.896835	0.070419	4.588187	0.296845	1.01E+15	1.93E+09	4.15E+09	2.61E+09	1.33E+08
0.562305	1.689784	0.021105	2.34675	0.155711	5.67E+13	1.47E+09	4.19E+09	3.12E+09	1.33E+08
0.588276	1.837859	0.031102	2.539069	0.167804	6.76E+13	1.52E+09	4.15E+09	3.08E+09	1.33E+08
0.627378	2.161601	0.062935	2.951223	0.191032	1.02E+14	1.63E+09	4.14E+09	2.99E+09	1.33E+08
0.654702	2.524489	0.103986	3.401029	0.213597	1.65E+14	1.67E+09	4.14E+09	2.94E+09	1.33E+08
0.673984	2.940057	0.139465	3.890039	0.235117	2.58E+14	1.76E+09	4.14E+09	2.86E+09	1.33E+08
0.674274	3.371866	0.166357	4.36748	0.25361	3.61E+14	1.79E+09	4.14E+09	2.83E+09	1.33E+08
0.646346	3.789988	0.190039	4.79972	0.267862	4.72E+14	1.79E+09	4.14E+09	2.82E+09	1.33E+08
0.595399	4.166272	0.210778	5.1646	0.279172	5.96E+14	1.79E+09	4.14E+09	2.81E+09	1.33E+08
0.529563	4.487809	0.219073	5.447005	0.287904	7.29E+14	1.79E+09	4.14E+09	2.81E+09	1.33E+08
0.466334	4.754666	0.196613	5.643355	0.293804	8.7E+14	1.78E+09	4.15E+09	2.8E+09	1.33E+08

0.414488	4.979989	0.158048	5.788432	0.296367	1.02E+15	1.77E+09	4.15E+09	2.8E+09	1.33E+08
0.562305	1.689784	0.021105	2.34675	0.155711	5.67E+13	1.47E+09	4.19E+09	3.12E+09	1.33E+08
0.588276	1.837859	0.031102	2.539069	0.167804	6.76E+13	1.52E+09	4.17E+09	3.09E+09	1.33E+08
0.637125	2.192407	0.065428	2.995137	0.193335	1.02E+14	1.65E+09	4.1E+09	2.99E+09	1.33E+08
0.698243	2.62967	0.11271	3.560156	0.22169	1.66E+14	1.72E+09	4.01E+09	2.99E+09	1.33E+08
0.787532	3.157347	0.161101	4.24101	0.250347	2.6E+14	1.81E+09	3.97E+09	2.94E+09	1.33E+08
0.884166	3.764428	0.209311	5.005437	0.277114	3.65E+14	1.85E+09	3.95E+09	2.94E+09	1.33E+08
0.948753	4.446783	0.262861	5.820303	0.301035	4.78E+14	1.86E+09	3.94E+09	2.93E+09	1.33E+08
0.974094	5.186523	0.321047	6.661779	0.322993	6.06E+14	1.87E+09	3.94E+09	2.92E+09	1.33E+08
0.969416	5.947262	0.373256	7.490486	0.342737	7.41E+14	1.87E+09	3.96E+09	2.91E+09	1.33E+08
0.939662	6.673673	0.405154	8.240856	0.360152	8.82E+14	1.85E+09	3.97E+09	2.85E+09	1.33E+08
0.895933	7.326991	0.415763	8.88191	0.374544	1.03E+15	1.79E+09	3.97E+09	2.84E+09	1.33E+08

Population	Primary energy	Primary energy (kWh)	Primary energy (biomass)	Primary energy (biomass, CCS)	Primary energy (biomass, no CCS)	Primary energy (coal)	Primary energy (coal, CCS)	Primary energy (coal, no CCS)	Primary energy (fossil)
6.53E+09	127506.5	1.28E+14	12189.23	0	12189.23	32633.64	0	32633.64	109509.2
6.92E+09	140522.9	1.41E+14	14643.98	0	14643.98	40273.48	0	40273.48	119306.7
7.58E+09	134227.2	1.34E+14	11990.98	140.9918	11849.98	34527.19	120.6701	34406.53	113206.1
8.06E+09	110156.5	1.1E+14	20613.99	3021.166	17592.83	16470.12	953.0302	15517.09	79128.61
8.39E+09	111005.6	1.11E+14	29409.22	10696.46	18712.75	8282.232	2887.677	5394.557	61573.77
8.53E+09	119748.8	1.2E+14	34317.82	12791.2	21526.62	6841.367	4424.162	2417.204	57092.62
8.49E+09	128479.7	1.28E+14	40222.34	15553.98	24668.35	6930.714	5514.59	1416.125	54961.22
8.3E+09	137459.5	1.37E+14	47747.57	20259.06	27488.51	7330.331	6142.322	1188.01	54024.19
7.97E+09	140298.4	1.4E+14	56347.81	27356.82	28991	6457.594	5491.521	966.0736	44656.66
7.51E+09	137720.8	1.38E+14	62194.07	34645.58	27548.49	4876.918	4085.85	791.0651	33590.62
6.96E+09	136097.9	1.36E+14	70508.27	45113.31	25394.95	3255.958	2618.423	637.5341	25282.96
6.53E+09	127506.5	1.28E+14	12189.23	0	12189.23	32633.64	0	32633.64	109509.2
6.92E+09	140522.9	1.41E+14	14643.98	0	14643.98	40273.48	0	40273.48	119306.7
7.58E+09	151275.3	1.51E+14	11014.77	0	11014.77	42285.98	2.84E-09	42285.98	131123.7
8.06E+09	154763.2	1.55E+14	12389.8	52.76076	12337.04	36780.56	1335.672	35444.89	129781.9
8.39E+09	153665.8	1.54E+14	18131.36	1751.949	16379.42	26951.9	5832.091	21119.81	116841.1
8.53E+09	153389.3	1.53E+14	23464.24	4756.71	18707.53	18539.14	8407.348	10131.79	102672.9
8.49E+09	158911.4	1.59E+14	32872.1	10304.86	22567.23	15014.98	11706.57	3308.408	90941.37
8.3E+09	158221.8	1.58E+14	41543.3	16763.94	24779.36	14367.71	12411.99	1955.721	76645.46
7.97E+09	157879	1.58E+14	55793.83	28655.77	27138.04	12578.08	11054.59	1523.491	59787.71
7.51E+09	158289.8	1.58E+14	66638.52	39165.2	27473.31	11261.57	10030.36	1231.206	49973.56
6.96E+09	156394.2	1.56E+14	62781.53	36276.28	26505.25	8338.345	7432.556	905.7888	46627.2
6.53E+09	127506.5	1.28E+14	12189.23	0	12189.23	32633.64	0	32633.64	109509.2
6.92E+09	140525.9	1.41E+14	14646.92	0	14646.92	40273.48	0	40273.48	119306.7
7.58E+09	155715.4	1.56E+14	11252.4	7.88E-23	11252.4	44046.31	7.93E-12	44046.31	135275.6
8.06E+09	169845.2	1.7E+14	13093.22	7.81E-23	13093.22	44899.51	2.477002	44897.04	144792.9
8.39E+09	178956.8	1.79E+14	18000.32	0.123326	18000.2	40592.53	53.12379	40539.39	144226.8
8.53E+09	184000.4	1.84E+14	20752.4	5.017215	20747.38	32955.61	529.9107	32425.69	137958.8
8.49E+09	187263.1	1.87E+14	24465.51	253.6492	24211.86	27213.13	2370.079	24843.05	129051.1
8.3E+09	179345.9	1.79E+14	30121.7	2105.921	28015.77	22662.58	5511.157	17151.43	107133.8
7.97E+09	169400	1.69E+14	41813.31	9112.124	32701.19	18206.16	8962.351	9243.813	80879.55
7.51E+09	165868.5	1.66E+14	62080.66	25855.17	36225.47	14389.21	10271.57	4117.645	57441.29
6.96E+09	165015.8	1.65E+14	70170.03	34933.95	35236.08	12148.58	10041.49	2107.086	48191.06
6.53E+09	127506.5	1.28E+14	12189.23	0	12189.23	32633.64	0	32633.64	109509.2
6.92E+09	140525.8	1.41E+14	14646.91	0	14646.91	40273.48	0	40273.48	119306.7
7.58E+09	155802.8	1.56E+14	11396.36	1.08E-18	11396.36	44106.95	7.28E-12	44106.95	135219.2
8.06E+09	172942	1.73E+14	12977.31	0.016411	12977.29	46954.2	1.325356	46952.87	148165.1
8.39E+09	190374.2	1.9E+14	18475.18	0.016344	18475.17	48287.18	9.159227	48278.01	156157.1
8.53E+09	203849.9	2.04E+14	22204.2	0.010623	22204.19	46717.23	25.01852	46692.2	158847.5

8.49E+09	210474.7	2.1E+14	24885.73	7.78E-10	24885.73	44522.37	77.21906	44445.15	155585.8
8.3E+09	205567.5	2.06E+14	29157.43	0	29157.44	37478.48	196.0579	37282.42	137315.2
7.97E+09	192802.1	1.93E+14	35171.66	325.1986	34846.44	28094.72	1052.072	27042.63	110902.5
7.51E+09	178457.8	1.78E+14	40532.85	2263.475	38269.36	21122.44	2217.006	18905.43	87917.8
6.96E+09	167527.3	1.68E+14	45376.43	5987.744	39388.7	15671.51	2915.952	12755.56	71619.78
6.53E+09	127506.5	1.28E+14	12189.23	0	12189.23	32633.64	0	32633.64	109509.2
6.92E+09	140525.8	1.41E+14	14646.91	0	14646.91	40273.48	0	40273.48	119306.7
7.58E+09	155872.5	1.56E+14	11418.31	0	11418.32	44139.42	0	44139.42	135266.2
8.06E+09	173548.7	1.74E+14	13686.35	0	13686.35	47379.18	0	47379.18	148106.2
8.39E+09	193462.3	1.93E+14	18991.19	0	18991.19	50182.82	0	50182.82	158948.3
8.53E+09	207845.3	2.08E+14	21670.64	0	21670.64	50124.51	0	50124.51	164078.1
8.49E+09	219041.4	2.19E+14	24600.7	0	24600.7	51326.15	0	51326.15	165890.4
8.3E+09	223149.4	2.23E+14	29450.52	0	29450.52	50600.73	0	50600.73	157242
7.97E+09	216925.3	2.17E+14	35451.79	0	35451.81	43926.92	0	43926.92	136479
7.51E+09	206976.1	2.07E+14	38445.68	0	38445.67	37935.2	0	37935.2	119650
6.96E+09	194629.4	1.95E+14	38153.77	0	38153.78	32105.33	0	32105.33	107512.9
6.5E+09	129006.5	1.29E+14	13458.9	0	13458.9	33692.53	0	33692.53	109543.4
6.87E+09	138899.8	1.39E+14	14984.18	0	14984.18	38891.42	0	38891.42	116293.4
7.61E+09	159629.8	1.6E+14	17330.57	0	17330.57	37893.64	0	37893.64	129663.4
8.26E+09	141433.7	1.41E+14	20364.18	266.1113	20098.07	9786.397	2728.336	7058.061	95372.3
8.79E+09	142332.9	1.42E+14	25135.02	1522.779	23612.24	6651.394	6156.672	494.7226	73132.28
9.17E+09	152746.8	1.53E+14	33109.47	5526.949	27582.52	10642.79	10602.23	40.55559	55450.04
9.38E+09	168209	1.68E+14	42126.98	13136.4	28990.58	8932.507	8917.507	15.00001	39760.87
9.46E+09	181052.6	1.81E+14	48952.82	27761.97	21190.85	4311.115	4302.226	8.888896	26347.24
9.41E+09	193344.9	1.93E+14	54132.54	40837.25	13295.29	1094.445	1088.89	5.55556	18950.02
9.25E+09	206819.3	2.07E+14	58930.6	44765.04	14165.57	217.5002	214.1668	3.333336	15445.57
9.03E+09	222859.1	2.23E+14	62648.11	47494.2	15153.9	13.05557	11.11112	1.944446	15462.51
6.5E+09	129017.3	1.29E+14	13458.9	0	13458.9	33694.75	0	33694.75	109554
6.87E+09	139161.8	1.39E+14	15274.46	0	15274.46	38813.09	0	38813.09	116264
7.61E+09	159448.7	1.59E+14	17797.79	0	17797.79	37556.7	17.22224	37539.47	128902.6
8.26E+09	163324.3	1.63E+14	19396.13	237.778	19158.35	23032.24	1695.557	21336.68	122542
8.79E+09	171783.7	1.72E+14	21005.29	994.1675	20011.13	13065.01	5404.449	7660.562	119432
9.17E+09	183343.2	1.83E+14	24245.57	3158.614	21086.96	15443.62	12945.84	2497.78	114314
9.38E+09	199899.6	2E+14	28588.36	9284.73	19303.63	24227.24	22893.07	1334.168	111007.3
9.46E+09	217426.6	2.17E+14	35692.81	22445.02	13247.79	35891.7	35442.25	449.4448	102071.2
9.41E+09	231093.2	2.31E+14	43533.92	33042.53	10491.4	36787.81	36782.25	5.55556	87146.46
9.25E+09	244039.4	2.44E+14	51089.49	39203.36	11886.12	31039.47	31036.14	3.333336	69799.22
9.03E+09	257848	2.58E+14	57251.71	43766.7	13485.01	24071.69	24069.74	1.944446	54516.99
6.5E+09	129017.3	1.29E+14	13458.9	0	13458.9	33694.75	0	33694.75	109554
6.87E+09	139165.4	1.39E+14	15278.35	0	15278.35	38813.09	0	38813.09	116264
7.61E+09	159607.6	1.6E+14	17420.57	0	17420.57	37706.42	15.27779	37691.14	129517.3
8.26E+09	174954.6	1.75E+14	17586.96	80.8334	17506.13	33687.25	894.7229	32792.53	139250.1
8.79E+09	187281.5	1.87E+14	18350.85	460.0004	17890.85	23715.57	3658.892	20056.68	142471.5
9.17E+09	201362.9	2.01E+14	21133.91	1780.557	19353.35	19653.63	8378.062	11275.56	144348.4
9.38E+09	214165.2	2.14E+14	24198.35	5903.894	18294.46	22847.52	14919.46	7928.062	140312.1
9.46E+09	232415.5	2.32E+14	26995.85	15224.73	11771.12	31044.19	25329.46	5714.727	139195.9
9.41E+09	252905.5	2.53E+14	31590.3	23555.57	8034.729	41338.92	39002.25	2336.669	138747.6

9.25E+09	269446	2.69E+14	38752.53	29302.52	9450.008	49179.21	48378.09	801.1118	127208.2
9.03E+09	288174.4	2.88E+14	46574.76	35548.64	11026.12	51839.76	51805.6	34.16669	115169.3
6.5E+09	129017.3	1.29E+14	13458.9	0	13458.9	33694.75	0	33694.75	109554
6.87E+09	139165.4	1.39E+14	15278.35	0	15278.35	38813.09	0	38813.09	116264.3
7.61E+09	160070.4	1.6E+14	17370.29	0	17370.29	38353.92	0	38353.92	130229.5
8.26E+09	179036.8	1.79E+14	17160.85	25.2778	17135.57	38740.03	346.1114	38393.92	144261.2
8.79E+09	196385.4	1.96E+14	17088.07	142.2223	16945.85	33484.75	1703.335	31781.41	155036.8
9.17E+09	214261.3	2.14E+14	18476.13	586.6671	17889.46	30908.64	5020.837	25887.8	163824.3
9.38E+09	229290.7	2.29E+14	20176.41	1820.557	18355.85	33399.47	11221.12	22178.35	167072.1
9.46E+09	243040.2	2.43E+14	22259.74	5184.449	17075.29	38271.98	19853.9	18418.07	165195.7
9.41E+09	260373.3	2.6E+14	24595.02	11758.9	12836.12	43565.31	29096.97	14468.34	163627.4
9.25E+09	279042.2	2.79E+14	27836.69	18777.79	9058.896	53358.38	43009.76	10348.62	157533.2
9.03E+09	305544.1	3.06E+14	32229.19	24352.52	7876.673	68722.28	63929.77	4792.504	161585.7
6.5E+09	129017	1.29E+14	13458.9	0	13458.9	33694.47	0	33694.47	109553.7
6.87E+09	139161.8	1.39E+14	15274.46	0	15274.46	38812.81	0	38812.81	116264
7.61E+09	160310.7	1.6E+14	17381.96	0	17381.96	38659.75	0	38659.75	130570.4
8.26E+09	182806.5	1.83E+14	17037.79	0	17037.79	42910.31	0	42910.31	148844.6
8.79E+09	204459.9	2.04E+14	16174.74	0	16174.74	44336.42	0	44336.42	166399.6
9.17E+09	227378.8	2.27E+14	16495.57	0	16495.57	47896.7	0	47896.7	183940.4
9.38E+09	248426	2.48E+14	17971.68	0	17971.68	55058.66	362.7781	54695.88	195511
9.46E+09	265272.4	2.65E+14	18246.96	0	18246.96	58150.05	2219.168	55930.88	202806.6
9.41E+09	284167.2	2.84E+14	17404.46	8.33334	17396.13	56418.93	7422.784	48996.15	210638.5
9.25E+09	306963.9	3.07E+14	17303.07	95.27785	17207.79	59381.16	18522.24	40858.92	221507.4
9.03E+09	328998.3	3.29E+14	19467.79	390.2781	19077.52	61118.38	30116.41	31001.97	225453
6.5E+09	129010.4	1.29E+14	13458.9	0	13458.9	33694.19	0	33694.19	109547
6.87E+09	139165.1	1.39E+14	15278.35	0	15278.35	38815.03	0	38815.03	116263.7
7.61E+09	161229.9	1.61E+14	17294.46	0	17294.46	39936.42	0	39936.42	131791.2
8.26E+09	185232.6	1.85E+14	17037.79	0	17037.79	45964.48	0	45964.48	151721
8.79E+09	208555.2	2.09E+14	16174.74	0	16174.74	50296.71	0	50296.71	171801
9.17E+09	233989.1	2.34E+14	16525.57	0	16525.57	57548.38	0	57548.38	192900.7
9.38E+09	258524.7	2.59E+14	17641.4	0	17641.4	69682.28	0	69682.28	210044.1
9.46E+09	280951.3	2.81E+14	18025.57	0	18025.57	81073.4	0	81073.4	224654.3
9.41E+09	309209.4	3.09E+14	17019.18	0	17019.18	93888.13	0	93888.13	247856.9
9.25E+09	336089.7	3.36E+14	16700.29	0	16700.29	100412.6	0	100412.6	266073.3
9.03E+09	362293.1	3.62E+14	18238.9	0	18238.9	99746.47	0	99746.47	279144.9
6.49E+09	124524	1.25E+14	12818.37	0	12818.37	32846.03	0	32846.03	105894.7
6.88E+09	135713	1.36E+14	13716.59	0	13716.59	37076	0	37076	115641.1
7.7E+09	165573	1.66E+14	16130.79	0	16130.79	45350.12	0	45350.12	141071.5
8.51E+09	185667	1.86E+14	19284.13	0	19284.13	47411.87	0	47411.87	154019.8
9.26E+09	169361.3	1.69E+14	26438.72	1276.64	25162.08	26163.3	4444.892	21718.41	124935.2
9.96E+09	181855.5	1.82E+14	38337.23	9403.869	28933.33	26968.91	13156.43	13812.48	122878
1.06E+10	193742	1.94E+14	48992.04	20289.32	28702.72	30411.02	21014.29	9396.73	121138.9
1.11E+10	196283.7	1.96E+14	64587.41	31976.89	32610.5	24195.99	16816.37	7379.617	101886.6
1.16E+10	199079.9	1.99E+14	76623.45	40594.2	36029.28	19479.65	13630.18	5849.477	85267.15
1.21E+10	203101.6	2.03E+14	87363.76	48110.9	39252.84	15511.4	10878.12	4633.281	69998.58
1.26E+10	209181.6	2.09E+14	96308.16	53968.9	42339.26	12291.34	8596.646	3694.725	57958.16
6.49E+09	124524	1.25E+14	12818.37	0	12818.37	32846.03	0	32846.03	105894.7

6.88E+09	135713	1.36E+14	13716.59	0	13716.59	37076	0	37076	115641.1
7.7E+09	165573	1.66E+14	16130.79	0	16130.79	45350.12	0	45350.12	141071.5
8.51E+09	191437.9	1.91E+14	18960.32	0	18960.32	51601.04	0	51601.04	160545.1
9.26E+09	188665.6	1.89E+14	23507.77	0	23507.77	38267.61	1954.557	36313.06	149665.8
9.96E+09	195560.6	1.96E+14	33105.28	967.8619	32137.41	35268.17	11360.81	23907.32	144541.7
1.06E+10	202362.6	2.02E+14	47124.23	10754.09	36370.14	34590.28	22065.68	12524.59	134186.2
1.11E+10	210547.6	2.11E+14	54306.49	23162.71	31143.77	34584.69	23017.07	11567.62	132748.8
1.16E+10	218324	2.18E+14	63506.97	29223.63	34283.31	34463.28	23593.07	10870.2	127886.2
1.21E+10	224937.9	2.25E+14	74046.28	36492.67	37553.61	32608.19	22686.85	9921.341	118715.5
1.26E+10	229673.5	2.3E+14	86118.29	44919.67	41198.62	28089.66	19769.27	8320.423	103916.3
6.49E+09	124524	1.25E+14	12818.37	0	12818.37	32846.03	0	32846.03	105894.7
6.88E+09	135713	1.36E+14	13716.59	0	13716.59	37076	0	37076	115641.1
7.7E+09	165573	1.66E+14	16130.79	0	16130.79	45350.12	0	45350.12	141071.5
8.51E+09	191951.8	1.92E+14	18937.9	0	18937.9	52050.32	0	52050.32	161107.4
9.26E+09	199151.6	1.99E+14	23073.66	0	23073.66	46818.15	10.00001	46808.15	161696.2
9.96E+09	208203.7	2.08E+14	31078.8	0	31078.8	45378.93	1425.557	43953.4	161449.4
1.06E+10	220011.6	2.2E+14	39885.23	0	39885.23	47825.9	2669.252	45156.65	163803
1.11E+10	226980.1	2.27E+14	50021.12	0	50021.12	44537.79	9943.23	34594.56	158761.7
1.16E+10	236029.6	2.36E+14	57836.55	1434.807	56401.74	45741.54	21087.85	24653.69	157453.1
1.21E+10	250451.3	2.5E+14	65085.64	6482.866	58602.77	51320.01	32542.28	18777.74	162192.5
1.26E+10	265332.6	2.65E+14	74770.25	13367.59	61402.69	55316.07	36210.64	19105.43	164454.7
6.49E+09	124524	1.25E+14	12818.37		12818.37	32846.03		32846.03	105894.7
6.88E+09	136034.6	1.36E+14	13717.01		13717.01	37336.89		37336.89	116045.4
7.7E+09	169330.7	1.69E+14	16105.07		16105.07	48745.98		48745.98	145494.2
8.51E+09	201343.5	2.01E+14	18875.24		18875.24	61735.99		61735.99	173592.2
9.26E+09	225965.8	2.26E+14	21668.68		21668.68	73254.61		73254.61	194610
9.96E+09	246447.1	2.46E+14	24989.85		24989.85	85183.04		85183.04	210929.1
1.06E+10	263180	2.63E+14	28704.88		28704.88	96364.27		96364.27	223479
1.11E+10	280431.1	2.8E+14	33016.92		33016.92	108906.9		108906.9	236281.1
1.16E+10	297704	2.98E+14	37370.14		37370.14	121754.5		121754.5	248912.5
1.21E+10	317093.3	3.17E+14	41596.17		41596.17	135694.5		135694.5	263805.9
1.26E+10	337567.3	3.38E+14	46719.59		46719.59	150782.3		150782.3	278826.9
6.9E+09	141284.2	1.41E+14	14313.92	0	14313.92	39794.41	0	39794.41	120328.8
7.63E+09	173532.7	1.74E+14	19400.04	256.5958	19143.44	51708.12	344.5803	51363.54	143936.1
8.26E+09	183609.4	1.84E+14	31665.72	6018.704	25647.01	32835.05	12092.38	20742.67	128154.8
8.77E+09	198757.7	1.99E+14	40305.84	13933.32	26372.51	26835.34	19610.57	7224.764	122475.9
9.15E+09	209252.8	2.09E+14	49105.29	24119.78	24985.51	24225.64	21178.37	3047.269	113118.5
9.38E+09	216301.2	2.16E+14	63089.61	37924.87	25164.75	20214.12	18659.67	1554.453	96120.87
9.47E+09	217485.1	2.17E+14	78146.04	51664.03	26482.02	13374.22	12543.4	830.8276	71826.87
9.47E+09	216523.6	2.17E+14	92835.82	64613.29	28222.53	5479.683	4992.231	487.4519	45792.85
9.4E+09	219417.4	2.19E+14	106360.7	76610.37	29750.35	1681.948	1392.352	289.5965	27599.38
9.29E+09	230036.5	2.3E+14	124492.4	93071.84	31420.6	627.5137	458.7289	168.7848	16097.24
6.9E+09	141284.2	1.41E+14	14313.92	0	14313.92	39794.41	0	39794.41	120328.8
7.63E+09	173532.7	1.74E+14	19400.04	256.6363	19143.4	51708.12	344.8164	51363.3	143936.1
8.26E+09	194984.7	1.95E+14	27426.87	2294.815	25132.05	47370.93	4609.206	42761.73	149918.2

8.77E+09	207231.2	2.07E+14	33028.67	5514.391	27514.28	37223.19	11385.57	25837.62	145081.7
9.15E+09	212061.1	2.12E+14	38093.05	10387.56	27705.48	27099.04	17085.77	10013.27	132825.2
9.38E+09	216842	2.17E+14	46503.87	19782.02	26721.86	22640.01	18766.32	3873.688	118941.7
9.47E+09	218968.3	2.19E+14	57363.38	32411.59	24951.79	18274.28	16518.9	1755.385	100466.3
9.47E+09	218956.8	2.19E+14	71625.36	46273.4	25351.96	13521.79	12612.64	909.1496	77799.67
9.4E+09	216900.1	2.17E+14	86277.87	59719.52	26558.34	6646.813	6129.193	517.6205	52321.45
9.29E+09	218409.7	2.18E+14	99370.15	71684.5	27685.65	2104.283	1797.962	306.3215	33403.56
6.9E+09	141284.2	1.41E+14	14313.92	0	14313.92	39794.41	0	39794.41	120328.8
7.63E+09	173532.7	1.74E+14	19400.04	256.6436	19143.4	51708.12	344.8921	51363.23	143936.1
8.26E+09	200348.1	2E+14	25612.62	1525.493	24087.13	53445.12	3039.84	50405.28	159004.4
8.77E+09	216621.8	2.17E+14	30666.46	3275.875	27390.58	49044.43	6725.164	42319.27	161781
9.15E+09	220619.8	2.21E+14	34395.86	5724.17	28671.69	37335.38	11642.86	25692.52	151252.6
9.38E+09	220727.2	2.21E+14	39518.7	10634.08	28884.62	26588.62	15676.33	10912.28	134772.2
9.47E+09	219821.8	2.2E+14	45882.18	18729.28	27152.9	20020.1	16326.38	3693.719	117277
9.47E+09	220997.3	2.21E+14	48041.16	21813.12	26228.03	17452.12	14525.99	2926.133	112253.6
9.4E+09	220583.4	2.21E+14	48623.49	23674.71	24948.78	15508.67	13288.8	2219.863	107892.5
9.29E+09	218506.2	2.19E+14	52151.41	28675.8	23475.61	12326	10928.34	1397.659	97508.85
6.9E+09	141284.2	1.41E+14	14313.92	0	14313.92	39794.41	0	39794.41	120328.8
7.63E+09	173532.7	1.74E+14	19400.04	256.5135	19143.53	51708.12	344.8078	51363.31	143936.1
8.26E+09	209801.3	2.1E+14	23207.31	914.2945	22293.02	64510.97	2365.196	62145.78	172507.4
8.77E+09	232063.1	2.32E+14	26633.43	1533.464	25099.96	68737.78	4158.549	64579.23	186167.7
9.15E+09	244353	2.44E+14	29312.58	2023.798	27288.79	68446.54	5382.993	63063.55	190809.2
9.38E+09	251239	2.51E+14	32091.5	2746.17	29345.33	67511.44	6656.937	60854.5	189484.2
9.47E+09	251107	2.51E+14	33085.34	3280.176	29805.16	62209.9	7054.416	55155.49	182808.6
9.47E+09	242889.5	2.43E+14	33690.07	3964.068	29726	47626.63	7240.684	40385.94	166192.1
9.4E+09	233088.3	2.33E+14	33954.56	5088.693	28865.87	32378.78	7502.981	24875.8	147573.8
9.29E+09	223909.7	2.24E+14	34908.63	7396.419	27512.21	18350.07	7882.814	10467.26	128482.7
6.51E+09	128072.8	1.28E+14	12864.46	0	12864.46	34545.15	0	34545.15	109340.4
6.9E+09	141284.2	1.41E+14	14313.92	0	14313.92	39794.41	0	39794.41	120328.8
7.63E+09	177155.5	1.77E+14	18655.26	0	18655.26	54781.43	0	54781.43	148733
8.26E+09	213229.5	2.13E+14	23288.59	0	23288.59	69713.97	0	69713.97	176269
8.77E+09	237453.6	2.37E+14	26857.74	0	26857.74	77252.11	0	77252.11	192126.9
9.15E+09	251486	2.51E+14	29310.79	0	29310.79	79938.32	0	79938.32	199217.8
9.38E+09	260830.1	2.61E+14	31757.59	0	31757.59	83287.46	0	83287.46	201534
9.47E+09	263368.2	2.63E+14	32427.97	0	32427.97	82124.5	0	82124.5	199047.1
9.47E+09	258711.5	2.59E+14	32312.19	0	32312.19	73080.15	0	73080.15	189021.4
9.4E+09	254316.9	2.54E+14	31633.38	0	31633.38	66124.71	0	66124.71	180965.1
9.29E+09	250994.6	2.51E+14	30774.14	0	30774.14	60609.39	0	60609.39	175228.2
6.51E+09	129055.7	1.29E+14	15508.35	0	15508.35	33944.47	0	33944.47	107611.2
6.89E+09	139639	1.4E+14	16619.46	0	16619.46	37611.14	0	37611.14	116416.8
7.55E+09	172166.8	1.72E+14	18277.79	0.944445	18277.79	32888.92	1.000001	32888.92	145639
8.05E+09	177250.1	1.77E+14	16463.9	2750.836	13713.9	15450.01	1.750001	15447.23	147000.1
8.4E+09	171805.7	1.72E+14	39444.48	31805.58	7630.562	4155.559	1.777779	4152.781	99527.86
8.58E+09	198333.5	1.98E+14	86138.96	82222.29	3905.559	1030.834	1.500001	1029.445	49277.82
8.59E+09	213277.9	2.13E+14	100472.3	98416.75	2055.002	422.5003	1.055556	421.3892	18605.57

8.46E+09	239694.6	2.4E+14	108611.2	104527.9	4083.337	341.9447	0.916667	341.1114	9911.119
8.2E+09	265639.1	2.66E+14	115833.4	109250.1	6566.672	315.8336	0.88889	315.0003	5850.005
7.83E+09	286389.1	2.86E+14	117583.4	110527.9	7041.672	254.2224	0.88889	253.3335	4419.448
7.38E+09	303333.6	3.03E+14	119277.9	112083.4	7177.784	211.5002	0.88889	210.6113	3338.892
6.51E+09	129055.7	1.29E+14	15508.35	0	15508.35	33944.47	0	33944.47	107611.2
6.89E+09	139639	1.4E+14	16619.46	0	16619.46	37611.14	0	37611.14	116416.8
7.55E+09	172166.8	1.72E+14	18277.79	0.944445	18277.79	32888.92	1.000001	32888.92	145639
8.05E+09	196500.2	1.97E+14	15055.57	770.834	14286.12	16800.01	3.888892	16794.46	170500.1
8.4E+09	204583.5	2.05E+14	18763.9	9897.23	8869.452	5450.004	10.83334	5438.893	166305.7
8.58E+09	226639.1	2.27E+14	49555.6	44333.37	5211.115	1625.557	12.91668	1612.501	138916.8
8.59E+09	245528	2.46E+14	86805.63	83916.73	2897.225	976.6674	11.50001	965.2786	93916.74
8.46E+09	259889.1	2.6E+14	102416.7	100611.2	1805.279	841.3896	8.666674	832.7784	61000.05
8.2E+09	275805.8	2.76E+14	112777.9	110194.5	2571.669	835.5562	4.111114	831.3896	33972.25
7.83E+09	296111.3	2.96E+14	123805.7	113972.3	9830.563	795.834	1.111112	794.4451	14386.12
7.38E+09	316944.7	3.17E+14	132500.1	115889	16616.68	731.1117	0.88889	730.2784	7733.34
6.51E+09	129055.7	1.29E+14	15508.35	0	15508.35	33944.47	0	33944.47	107611.2
6.89E+09	139639	1.4E+14	16619.46	0	16619.46	37611.14	0	37611.14	116416.8
7.55E+09	172166.8	1.72E+14	18277.79	0.944445	18277.79	32888.92	1.000001	32888.92	145639
8.05E+09	200444.6	2E+14	15013.9	253.4446	14761.12	20536.13	242.9446	20291.68	175444.6
8.4E+09	217222.4	2.17E+14	12616.68	2875.002	9741.674	11405.56	2394.724	9011.118	190166.8
8.58E+09	241361.3	2.41E+14	18805.57	12516.68	6286.116	12350.01	8580.562	3769.447	196972.4
8.59E+09	261944.7	2.62E+14	39361.14	35527.81	3833.336	14155.57	12375.01	1779.724	177305.7
8.46E+09	273750.2	2.74E+14	63694.5	61416.72	2270.557	12263.9	11013.9	1250.001	136639
8.2E+09	286666.9	2.87E+14	88166.74	86666.74	1486.946	8280.562	7175.006	1107.223	89944.52
7.83E+09	301111.4	3.01E+14	110250.1	108972.3	1274.168	3408.336	2145.279	1263.612	48277.82
7.38E+09	313889.1	3.14E+14	116694.5	115527.9	1155.556	1499.723	136.9446	1362.779	31361.14
6.51E+09	129055.7	1.29E+14	15508.35	0	15508.35	33944.47	0	33944.47	107611.2
6.89E+09	139639	1.4E+14	16619.46	0	16619.46	37611.14	0	37611.14	116416.8
7.55E+09	172166.8	1.72E+14	18277.79	0.944445	18277.79	32888.92	1.000001	32888.92	145639
8.05E+09	202055.7	2.02E+14	15580.57	219.6668	15361.12	22016.68	458.6115	21558.35	176639
8.4E+09	223694.6	2.24E+14	13608.34	2401.669	11205.56	16736.12	4675.004	12061.12	196472.4
8.58E+09	255722.4	2.56E+14	18838.9	10241.67	8597.229	24277.8	18086.13	6188.894	214472.4
8.59E+09	284722.5	2.85E+14	32555.58	26050.02	6505.561	35055.58	32027.8	3033.336	214722.4
8.46E+09	301666.9	3.02E+14	46138.93	41472.26	4661.115	38944.48	36888.92	2056.391	197555.7
8.2E+09	317222.5	3.17E+14	56027.82	52694.49	3347.225	36055.58	34250.03	1818.613	177000.1
7.83E+09	325000.3	3.25E+14	64250.05	61888.94	2360.002	30583.36	28777.8	1803.613	150222.3
7.38E+09	338889.2	3.39E+14	66055.61	64333.38	1727.224	29833.36	28055.58	1796.946	145250.1
6.51E+09	129055.7	1.29E+14	15508.35	0	15508.35	33944.47	0	33944.47	107611.2
6.89E+09	139639	1.4E+14	16619.46	0	16619.46	37611.14	0	37611.14	116416.8
7.55E+09	172166.8	1.72E+14	18277.79	0.944445	18277.79	32888.92	1.000001	32888.92	145639
8.05E+09	209639.1	2.1E+14	15355.57	38.05559	15316.68	29250.02	486.3893	28750.02	185194.6
8.4E+09	243916.9	2.44E+14	12883.34	355.8336	12527.79	32111.14	5961.116	26158.35	220583.5
8.58E+09	285000.2	2.85E+14	13405.57	1411.112	11994.45	49972.26	28555.58	21419.46	256778
8.59E+09	325000.3	3.25E+14	15227.79	3302.78	11927.79	78972.29	63722.27	15255.57	285000.2
8.46E+09	345833.6	3.46E+14	17188.9	5861.116	11327.79	90666.74	81694.51	8969.452	286944.7
8.2E+09	354444.7	3.54E+14	19013.9	9150.007	9863.897	85277.85	80666.73	4588.893	270944.7
7.83E+09	355555.8	3.56E+14	21791.68	13538.9	8252.784	78861.17	76305.62	2569.447	244916.9

7.38E+09	365555.8	3.66E+14	25975.02	18127.79	7850.006	78055.62	75333.39	2739.169	231528
6.51E+09	129055.7	1.29E+14	15508.35	0	15508.35	33944.47	0	33944.47	107611.2
6.89E+09	139639	1.4E+14	16619.46	0	16619.46	37611.14	0	37611.14	116416.8
7.55E+09	174111.3	1.74E+14	18319.46	0	18319.46	38027.81	0	38027.81	147666.8
8.05E+09	219333.5	2.19E+14	15366.68	0	15366.68	45500.04	0	45500.04	195889
8.4E+09	270972.4	2.71E+14	12797.23	0	12797.23	64888.94	0	64888.94	250833.5
8.58E+09	325000.3	3.25E+14	13258.34	0	13258.34	98166.75	0	98166.75	303889.1
8.59E+09	384444.8	3.84E+14	14736.12	0	14736.12	147583.5	0	147583.5	359444.7
8.46E+09	437778.1	4.38E+14	16127.79	0	16127.79	195527.9	0	195527.9	406667
8.2E+09	482222.6	4.82E+14	17513.9	0	17513.9	230416.9	0	230416.9	440278.1
7.83E+09	498611.5	4.99E+14	19136.13	0	19136.13	243555.8	0	243555.8	439167
7.38E+09	506667.1	5.07E+14	20805.57	0	20805.57	246722.4	0	246722.4	425000.3

Primary energy (fossil, CCS)	Primary energy (fossil, no CCS)	Primary energy (gas)	Primary energy (gas, CCS)	Primary energy (geothermal)	Primary energy (hydro)	Primary energy (nuclear)	Primary energy (renewables excl. bio)	Primary energy (nuclear)	Primary energy (oil)
0	109509.2	28318.22	0		2931.677	28318.22	3098.927	2767.954	48557.37
0	119306.7	31332.39	0		3440.925	31332.39	3884.651	2756.29	47700.82
571.515	112634.6	35654.67	390.6875		4400.892	35264	6275.659	2853.655	43024.23
6935.883	72192.72	38605.11	5695.963		4935.918	32909.14	7578.488	3003.408	24053.38
23604.51	37969.27	41181.2	20185.81		5947.516	20995.39	18310.6	2227.568	12110.34
31148.43	25944.19	40893.76	26315.95		5483.807	14577.81	27915.25	1016.863	9357.499
33926.87	21034.34	40089.17	28246.49		5231.179	11842.67	33147.52	871.7987	7941.329
36837.4	17186.77	39527.67	30525.11		5738.335	9002.54	35662.13	960.1889	7166.192
30213.82	14442.84	31751.8	24530.01		6130.361	7221.795	39272.95	1182.995	6447.264
21301.26	12289.35	22818.14	17037.39		6194.5	5780.746	41828.41	1464.955	5895.558
13870.53	11412.43	16546.96	11131.09		6056.463	5415.868	40514.62	1359.365	5480.043
0	109509.2	28318.22	0		2931.677	28318.22	3098.927	2767.954	48557.37
0	119306.7	31332.36	0		3440.925	31332.36	3884.651	2756.29	47700.82
3.00E-09	131123.7	41295.31	1.58E-10		4556.901	41295.31	6324.403	2919.105	47542.43
1868.808	127913.1	51555.68	526.5546		5383.296	51029.13	9816.821	3060.619	41445.67
10140.78	106700.3	55996.1	4166.65		5999.935	51829.46	16883.14	2363.34	33893.08
14747.57	87925.35	53562.71	6182.03		6230.208	47380.68	26843.84	1084.737	30571.08
18815.68	72125.69	48288.79	7021.245		6429.991	41267.53	35140.68	785.5809	27637.6
19912.68	56732.77	38979.75	7482.451		6325.502	31497.3	40427.96	588.911	23297.99
19939.08	39848.65	32049.5	8872.154		6301.908	23177.35	42897.89	571.7749	15160.14
19093.7	30879.86	27997.83	9058.038		6765.514	18939.79	42369.18	689.0964	10714.16
16956.13	29671.06	28045.08	9517.127		6961.117	18527.94	47834.12	701.5105	10243.78
0	109509.2	28318.22	0		2931.677	28318.22	3098.927	2767.954	48557.37
0	119306.7	31332.36	0		3440.925	31332.36	3884.651	2756.29	47700.82
8.37E-12	135275.6	42589.37	4.41E-13		4598.673	42589.37	6361.318	2934.539	48639.93
2.538443	144790.4	55891.13	0.061438		5385.526	55891.07	9245.662	2999.972	44002.26
57.25755	144169.5	65486.11	4.13357		6049.594	65481.97	15119.81	2177.351	38148.14
615.9832	137342.8	68529.97	86.07193		6255.683	68443.92	25088.23	947.3177	36473.22
3056.676	125994.4	67958.83	685.5295		6488.066	67273.3	34040.48	619.5147	33879.11
8442.032	98691.8	55771.88	2928.716		6624.78	52843.15	42751.75	376.1914	28699.36
13363.46	67516.08	42743.84	4398.876		6678.28	38344.95	47652.62	236.2891	19929.55
15527.31	41914	30950.52	5251.743		6875.217	25698.8	47418.25	278.8533	12101.56
14694.42	33496.64	26678.17	4648.359		7019.072	22029.8	47877.7	335	9364.316
0	109509.2	28318.22	0		2931.677	28318.22	3098.927	2767.954	48557.37
0	119306.7	31332.36	0		3440.925	31332.36	3884.651	2756.29	47700.82
7.68E-12	135219.2	42507.67	4.04E-13		4598.912	42507.67	6360.015	2935.636	48604.62
1.386774	148163.8	56838.91	0.045007		5386.782	56838.85	9094.41	2991.8	44372.04
9.92956	156147.2	68494.2	0.753972		6051.113	68493.44	14175.72	2134.499	39375.7
26.12075	158821.4	73486.5	1.09152		6272.705	73485.42	22722.56	882.8207	38643.78

78.40413	155507.4	74419.59	1.18455		6497.588	74418.42	30461.77	528.5068	36643.84
197.6974	137117.5	67887.83	1.638347		6706.489	67886.19	39963.88	264.2906	31948.91
1695.452	109207	59156.41	643.3452		6833.006	58513.08	47904.96	95.19405	23651.38
3936.851	83980.94	50154.01	1714.132		6969.508	48439.87	51298.89	122.8914	16641.35
5311.243	66308.53	43509.04	2390.417		7163.386	41118.62	51954.24	135.8148	12439.23
0	109509.2	28318.22	0		2931.677	28318.22	3098.927	2767.954	48557.37
0	119306.7	31332.36	0		3440.925	31332.36	3884.651	2756.29	47700.82
0	135266.2	42489.37	0		4599.779	42489.37	6360.217	2936.33	48637.37
0	148106.2	56390.05	0		5386.874	56390.05	9051.183	2991.614	44336.95
0	158948.3	69147.58	0		6051.11	69147.58	13965.58	2125.479	39617.92
0	164078.1	74683.06	0		6276.297	74683.06	22045.46	869.3021	39270.56
0	165890.4	76821.54	0		6496.944	76821.54	29043.49	509.669	37742.73
0	157242	72854.59	0		6720.491	72854.59	37396.36	236.7996	33786.67
0	136479	66613.17	0		6871.064	66613.17	46286.1	57.27229	25938.95
0	119650	62399.55	0		7030.225	62399.55	50319.66	51.59282	19315.21
0	107512.9	60344.44	0		7301.445	60344.44	50564.1	35.60531	15063.13
0	109543.4	27911.69	0	99.44452	2946.113	27911.69	3237.503	2768.336	47939.21
0	116293.4	29323.63	0	151.9446	3576.392	29323.63	4876.948	2749.169	48078.37
0	129663.4	33891.14	0	168.889	4267.781	33891.14	9184.73	3453.058	57878.66
6235.283	89137.02	38870.31	3506.947	365.8336	5970.005	35363.36	20250.85	5455.004	46715.59
20047.52	53084.76	38767.25	13890.84	950.2785	7799.451	24876.41	34992.25	9094.174	27713.63
25348.63	30101.41	35501.14	14746.4	1472.779	8609.729	20754.74	47695.04	16512.79	9306.119
18163.63	21597.24	26995.02	9246.119	2060.002	9399.452	17748.9	59260.33	27138.08	3833.336
8315.284	18031.96	19141.4	4013.059	2512.502	9977.508	15128.35	73071.73	32922.8	2894.725
2209.446	16740.57	15645.29	1120.556	2736.947	10242.79	14524.73	86578.4	34019.19	2210.28
215.278	15230.29	13906.96	1.111112	2933.336	10421.4	13905.84	102266.2	30530.58	1321.112
11.66668	15450.85	14658.62	0.555556	3171.114	10539.18	14658.07	123195.1	22081.96	790.834
0	109554	27905.02	0	99.44452	2945.558	27905.02	3238.058	2768.336	47954.21
0	116264	29362.52	0	151.9446	3575.558	29362.52	4877.504	2749.169	48088.37
55.83338	128846.8	33747.53	38.61114	168.889	4267.226	33708.92	9243.063	3507.503	57598.38
3930.003	118612	42463.65	2234.446	153.0557	5359.171	40229.2	16335.29	5055.282	57046.16
15334.46	104097.6	53162.26	9930.008	148.3335	6021.949	43232.26	24062.8	7297.228	53204.76
38354.48	75959.51	59637.27	25408.63	227.2224	7393.061	34228.64	32752.25	12043.62	39233.09
51710.87	59296.44	60230.33	28817.8	342.5003	8125.007	31412.53	41453.92	18872.24	26549.74
57751.99	44319.2	54712.54	22309.74	573.3338	9145.285	32402.8	53331.99	26361.97	11466.95
51654.21	35492.25	46636.43	14871.96	1146.668	9863.619	31764.47	69556.17	30903.64	3722.225
39316.14	30483.08	37301.42	8280.007	1759.724	10396.4	29021.41	90428.96	32801.97	1458.335
26465.3	28051.69	29781.97	2395.557	2383.057	10535.29	27386.41	115114.3	31032.25	663.3339
0	109554	27905.02	0	99.44452	2945.558	27905.02	3238.058	2768.336	47954.21
0	116264	29362.52	0	151.9446	3575.558	29362.52	4877.504	2749.169	48088.37
35.83336	129481.5	34141.69	20.55557	168.889	4244.17	34121.14	9164.73	3507.503	57669.21
915.2785	138334.8	43725.59	20.55557	151.389	4766.115	43705.03	14507.23	3617.781	61837.27
4339.726	138131.8	56243.38	680.8339	38.61114	5940.283	55562.54	22214.74	4255.281	62512.55
11460.01	132888.4	67445.05	3081.947	89.72229	6376.672	64363.11	29388.63	6503.894	57249.77
26822.8	113489.3	72843.11	11903.34	159.4446	7497.784	60939.77	37856.97	11818.62	44621.42
51588.37	87607.57	73712.84	26258.91	241.6669	8322.784	47453.93	45204.76	21044.18	34438.92
67052	71695.61	76085.06	28049.74	415.0003	9012.785	48035.32	53647.54	28958.63	21323.63

70252.83	56955.32	67665.61	21874.74	720.5561	9917.508	45790.87	69633.67	33916.14	10363.34
66455.61	48713.65	58182.82	14650.01	1280.001	10352.51	43532.81	89136.74	37405.59	5146.671
0	109554	27905.02	0	99.44452	2945.558	27905.02	3238.058	2768.336	47954.21
0	116264.3	29362.8	0	151.9446	3575.558	29362.8	4877.504	2749.169	48088.37
0	130229.5	34211.97	0	168.889	4244.17	34211.97	8965.841	3507.225	57663.66
346.1114	143915.1	43577.26	0	148.889	4696.393	43577.26	14226.96	3394.725	61943.94
1703.335	153333.5	56675.05	0	36.11114	5748.893	56675.05	21045.85	3226.391	64877
5020.837	158803.5	68732	0	36.11114	6057.227	68732	27331.69	4641.948	64183.66
11390.56	155681.5	78478.95	169.4446	33.61114	6434.45	78309.51	34641.69	7412.506	55193.66
21178.35	144017.3	84290.07	1324.446	23.61113	7122.228	82965.62	41813.64	13790.57	42633.65
36531.97	127095.4	87881.74	7435.006	47.22226	8229.173	80446.73	48296.71	23896.96	32180.3
61373.38	96159.8	82461.73	18363.63	187.2224	9525.285	64098.11	57386.71	36337.53	21713.07
83489.23	78096.45	78515.34	19559.46	391.3892	9910.563	58955.88	68963.94	42823.37	14348.07
0	109553.7	27905.02	0	99.44452	2945.558	27905.02	3238.058	2768.336	47954.21
0	116264	29362.8	0	151.9446	3575.281	29362.8	4877.226	2749.169	48088.37
0	130570.4	34171.69	0	168.889	4180.837	34171.69	8867.229	3493.058	57738.94
0	148844.6	43297.26	0	143.889	4639.448	43297.26	13785.57	3146.114	62636.99
0	166399.6	56030.6	0	33.05558	5650.838	56030.6	19746.13	2152.502	66032.55
0	183940.4	68872.28	0	33.05558	5863.06	68872.28	25204.74	1750.557	67171.44
362.7781	195148.2	79365.06	0	31.11114	6127.505	79365.06	31990.86	2965.002	61087.27
2219.168	200587.4	89307.02	0	10.00001	6480.839	89307.02	38855.03	5381.949	55349.49
7422.784	203215.7	93322.02	0	13.8889	6741.672	93322.02	45566.7	10580.29	60897.55
18522.24	202985.2	94396.46	0	14.16668	7040.561	94396.46	52078.93	16098.9	67729.78
30116.41	195336.5	92480.35	0	14.72223	9180.285	92480.35	58406.16	25728.08	71854.22
0	109547	27905.02	0	99.44452	2945.28	27905.02	3237.78	2768.336	47947.82
0	116263.7	29359.75	0	151.9446	3575.281	29359.75	4877.226	2749.169	48088.93
0	131791.2	34281.97	0	168.889	4243.892	34281.97	8828.896	3317.225	57572.82
0	151721	43045.87	0	142.5001	4695.004	43045.87	13385.29	3096.114	62710.61
0	171801	54643.38	0	29.72225	5274.171	54643.38	18578.9	2014.724	66860.89
0	192900.7	66994.5	0	29.72225	5425.56	66994.5	23378.07	1198.612	68357.83
0	210044.1	77236.17	0	29.72225	5646.949	77236.17	29281.69	1570.001	63125.61
0	224654.3	85796.18	0	9.166674	6151.394	85796.18	35552.53	2737.502	57784.77
0	247856.9	89318.4	0	9.166674	6599.728	89318.4	39530.59	4827.504	64650.33
0	266073.3	90644.24	0	9.166674	6855.005	90644.24	44973.65	8362.229	75016.45
0	279144.9	96451.47	0	2.77778	6925.283	96451.47	52334.49	12592.79	82947.01
0	105894.7	27423.24	0	57.47227	2895.725	27423.24	3067.836	2743.086	45625.45
0	115641.1	29617.16	0	59.86116	3318.447	29617.16	3539.003	2816.28	48948.01
0	141071.5	36421.31	0	70.61117	4266.253	36421.31	4713.837	3656.808	59300.08
0	154019.8	42766.37	0	81.47229	5254.754	42766.37	6899.422	5463.643	63841.58
11614.73	113320.5	38722.56	4330.642	93.4723	7106.811	34391.89	11708.81	6278.533	60049.41
35108.69	87769.29	38623.5	12413.93	103.6112	7559.034	26209.58	15210.85	5429.393	57285.6
52559.46	68579.5	38312.98	17592.68	112.5556	7829.673	20720.29	19164.88	4446.115	52414.96
45702.65	56183.93	33424.53	15761.73	121.3334	8562.951	17662.79	25471.3	4338.42	44266.09
39679.14	45588.01	28865.11	14049.37	129.639	8831.646	14815.73	32772.97	4416.365	36922.39
33225.08	36773.5	24156.66	11917.93	137.889	8831.646	12238.7	41336.87	4402.309	30330.52
27564.72	30393.44	20368.32	10074.12	146.7501	8831.646	10294.2	50654.32	4260.976	25298.49
0	105894.7	27423.24	0	57.47227	2895.725	27423.24	3067.836	2743.086	45625.45

0	115641.1	29617.16	0	59.86116	3318.447	29617.16	3539.003	2816.28	48948.01
0	141071.5	36421.31	0	70.61117	4266.253	36421.31	4713.837	3656.808	59300.08
0	160545.1	42974.62	0	80.13895	5252.199	42974.62	6468.811	5463.643	65969.44
1954.557	147711.3	44420.92	0	90.13896	6609.894	44420.92	9345.702	6146.283	66977.28
16713.35	127828.4	44750.42	3952.031	100.0834	7350.728	40798.42	12145.43	5768.227	64523.11
37261.86	96924.27	42187.2	10201.59	108.9445	7861.84	31985.61	15779.48	5272.782	57408.71
48713.46	84035.35	43484.2	15962.15	117.6668	8232.368	27522.05	18842.88	4649.448	54679.9
54089.9	73796.31	42965.01	18268.82	126.0279	8496.59	24696.19	22622.27	4308.531	50457.93
52235.88	66479.58	40614.62	17735.15	134.3057	8710.563	22879.46	28021.77	4154.392	45492.65
47182.57	56733.77	36236.92	16287.46	143.2223	8831.646	19949.46	35355.36	4283.531	39589.73
0	105894.7	27423.24	0	57.47227	2895.725	27423.24	3067.836	2743.086	45625.45
0	115641.1	29617.16	0	59.86116	3318.447	29617.16	3539.003	2816.28	48948.01
0	141071.5	36421.31	0	70.61117	4266.253	36421.31	4713.837	3656.808	59300.08
0	161107.4	42949.62	0	79.77784	5252.032	42949.62	6442.866	5463.643	66107.44
10.00001	161686.2	46300.68	0	88.50007	6212.366	46300.68	8560.785	5820.949	68577.36
1425.557	160023.9	48751.73	0	97.55563	6937.561	48751.73	10676.95	4998.615	67318.75
2669.252	161133.8	51902.62	0	106.2501	7138.589	51902.62	12316.73	4006.614	64074.55
10789.76	147972	53039.82	628.0838	114.9168	7653.562	52411.74	14584.65	3612.614	61184.13
26165.24	131287.9	53762.15	3735.253	123.2779	7999.118	50026.9	17369.13	3370.892	57949.41
39802.7	122389.9	55262.63	5296.81	131.6112	8180.757	49965.82	20158.85	3014.225	55609.91
47474.15	116980.5	56505.6	8145.673	140.5834	8250.951	48359.93	23340.13	2767.53	52632.99
	105894.7	27423.24		57.47227	2895.725	27423.24	3067.836	2743.086	45625.45
	116045.4	29646.97		59.86116	3285.558	29646.97	3506.281	2765.863	49061.57
	145494.2	36493.72		71.47228	4064.031	36493.72	4353.781	3377.697	60254.49
	173592.2	44424.73		83.02784	4611.67	44424.73	4996.476	3879.586	67431.47
	194610	50597.21		94.33341	5355.893	50597.21	5857.838	3829.364	70758.14
	210929.1	56330.55		104.639	6515.283	56330.55	7142.061	3386.114	69415.5
	223479	61082.74		113.9445	7276.45	61082.74	8085.034	2911.002	66032.03
	236281.1	63799.02		123.0834	7567.589	63799.02	8588.59	2544.558	63575.13
	248912.5	66160.05		131.889	7839.09	66160.05	9172.868	2248.446	60997.97
	263805.9	68548.03		140.6946	8000.423	68548.03	9693.98	1997.252	59563.41
	278826.9	71143.83		150.1946	8046.701	71143.83	10192.06	1828.779	56900.82
0	120328.8	31623.58	0	68.09047	3441.928	31623.58	3885.209	2756.29	48910.83
707.2135	143228.9	39496.05	318.3804	469.7754	3616.626	39177.67	6168.852	4027.688	52731.9
17467.37	110687.4	45423.1	5034.82	1167.688	3795.765	40388.29	11726.16	12062.67	49896.65
30095.63	92380.31	48688.41	10023.66	1430.434	4058.205	38664.74	16951.54	19024.35	46952.2
35752.72	77365.74	46895.17	14035.87	1565.785	4403.956	32859.3	22163.32	24865.73	41997.65
35085.53	61035.34	43717.26	15946.6	1621.388	4749.599	27770.66	26302.74	30787.95	32189.48
27235.31	44591.56	35304.06	14290	1639.748	5094.836	21014.05	31341.02	36171.18	23148.58
15453.12	30339.73	25574.63	10137.06	1623.497	5441.199	15437.57	37026.74	40868.16	14738.53
7390.593	20208.78	17628.61	5786.589	1612.51	5786.946	11842.02	45173.37	40283.9	8288.816
2531.206	13566.04	11678.64	1988.198	1265.839	5959.822	9690.443	50866.17	38580.64	3791.088
0	120328.8	31623.58	0	68.09053	3441.928	31623.58	3885.209	2756.29	48910.83
707.4046	143228.7	39496.05	318.339	469.7754	3616.626	39177.71	6168.852	4027.688	52731.9
6888.525	143029.7	49954.42	2137.936	978.2611	3795.765	47816.48	9686.158	7953.476	52592.9

16499.1	128582.6	56089.66	4893.762	1282.377	4058.205	51195.89	14564.38	14556.43	51768.85
25720.32	107104.9	56176.43	8306.871	1456.892	4403.956	47869.56	19841.83	21301.06	49549.71
30700.9	88240.77	53248.76	11488.68	1546.93	4749.703	41760.09	24850.26	26546.2	43052.89
29472.94	70993.38	45832.1	12514.56	1561.718	5095.296	33317.53	29411.76	31726.84	36359.94
24691.28	53108.4	36926.21	11674.69	1521.411	5441.199	25251.52	33729.41	35802.4	27351.68
15379.66	36941.79	27570.14	8908.558	1477.904	5786.946	18661.58	40148.88	38151.89	18104.5
7557.5	25846.06	19658.02	5523.465	1398.719	5959.822	14134.56	47834.02	37802	11641.25
0	120328.8	31623.58	0	68.09053	3441.928	31623.58	3885.209	2756.29	48910.83
707.4499	143228.6	39496.05	318.3324	469.7754	3616.626	39177.72	6168.852	4027.688	52731.9
4557.867	154446.6	52105.7	1426.535	899.1416	3795.765	50679.16	9002.652	6728.393	53453.63
9801.421	151979.6	59348.6	2948.687	1157.488	4058.205	56399.91	12882.94	11291.36	53388
16850.89	134401.7	61396.45	5023.456	1337.083	4403.956	56372.99	17606.35	17365.04	52520.76
23681.33	111090.8	59669.5	7687.301	1475.188	4749.703	51982.2	23200.4	23235.91	48514.06
26264.24	91012.81	52649.51	9544.393	1522.486	5095.449	43105.12	28294.21	28368.33	44607.43
24203.66	88049.96	50794.26	9431.401	1391.703	5415.435	41362.86	30148.63	30553.85	44007.24
22570.91	85321.62	48953.51	9008.773	1273.387	5786.946	39944.74	32335.9	31731.46	43430.36
19361.89	78146.96	45252.47	8148.824	1204.465	5959.822	37103.65	36910.03	31935.89	39930.38
0	120328.8	31623.58	0	68.09053	3441.928	31623.58	3885.209	2756.29	48910.83
706.8287	143229.2	39496.05	318.0114	469.7754	3616.626	39178.04	6168.852	4027.688	52731.9
3273.608	169233.8	54349.48	858.5529	810.7903	3795.765	53490.93	8351.13	5735.447	53646.93
5585.957	180581.7	63197.94	1377.078	990.6374	4058.205	61820.86	11042.94	8219.01	54231.97
7233.215	183576	67461.09	1800.983	1057.927	4403.956	65660.11	13506.28	10724.9	54901.57
8921.723	180562.5	68039.08	2199.221	1101.617	4749.703	65839.86	16593.68	13069.57	53933.7
9314.527	173494.1	64743.65	2188.979	1129.148	5095.449	62554.67	19648.48	15564.6	55855.04
9757.382	156434.7	61582.88	2422.557	1203.616	5441.199	59160.32	24149.91	18857.5	56982.55
10540.88	137032.9	58840.44	2909.856	1224.087	5786.946	55930.58	29450.69	22109.21	56354.59
11837.55	116645.2	56529.85	3791.828	1192.915	5959.822	52738.03	35677.9	24840.48	53602.78
0	109340.4	27445.5	0	58.20096	2933.274	27445.5	3099.994	2767.953	47349.72
0	120328.8	31623.58	0	68.09053	3441.928	31623.58	3885.209	2756.29	48910.83
0	148733	40819.51	0	453.3049	3616.626	40819.51	5968.163	3799.105	53132.06
0	176269	54173.87	0	787.0885	3795.765	54173.87	8166.085	5505.814	52381.21
0	192126.9	62810.18	0	956.7709	4058.205	62810.18	10702.96	7765.958	52064.62
0	199217.8	67041.43	0	1012.887	4403.956	67041.43	13009.09	9948.332	52238.01
0	201534	67567.5	0	1039.765	4749.703	67567.5	15647.65	11890.85	50679.03
0	199047.1	64174.89	0	1034.629	5095.449	64174.89	18092	13801.12	52747.69
0	189021.4	61181.33	0	1063.596	5441.199	61181.33	21361.13	16016.76	54759.92
0	180965.1	58973.56	0	1045.101	5786.946	58973.56	24441.55	17276.88	55866.81
0	175228.2	58411.9	0	992.6888	5959.822	58411.9	27340.7	17651.61	56206.87
0	107611.2	27244.47	0	60.91672	2969.447	27244.47	3138.891	2811.113	46444.48
0	116416.8	31166.69	0	91.05563	3144.447	31166.69	3786.114	2830.558	47638.93
2.166668	145639	47083.37	1.194445	112.8334	2988.891	47083.37	4888.893	3377.78	65666.72
531.1115	146472.3	42722.26	529.1671	366.1114	3686.114	42194.48	7961.117	5822.227	88833.4
2947.225	96583.41	26380.58	2944.447	1448.612	7633.339	23436.13	21419.46	11402.79	69000.06
3572.225	45722.26	16077.79	3569.447	4402.781	10950.01	12508.34	46833.37	16086.12	32166.69
3575.003	15030.57	10050.01	3575.003	7825.006	12011.12	6477.783	75555.62	18630.57	8133.34

2441.669	7469.45	5825.005	2440.558	10741.68	12402.79	3383.336	101194.5	19997.24	3744.447
832.2229	5019.448	2505.28	831.3896	12180.57	12733.34	1673.89	124277.9	19683.35	3030.558
331.6669	4088.892	1533.89	330.8336	12500.01	13027.79	1203.057	145805.7	18658.35	2632.224
38.4167	3300.003	718.3339	37.52781	12775.01	13230.57	680.8339	163222.4	17413.9	2409.169
0	107611.2	27244.47	0	60.91672	2969.447	27244.47	3138.891	2811.113	46444.48
0	116416.8	31166.69	0	91.05563	3144.447	31166.69	3786.114	2830.558	47638.93
2.166668	145639	47083.37	1.194445	112.8334	2988.891	47083.37	4888.893	3377.78	65666.72
1208.612	169277.9	60916.72	1204.723	231.1946	3169.447	59722.27	6172.227	4775.004	92777.85
11869.45	154416.8	65583.39	11858.34	465.8337	4994.448	53750.04	11402.79	8122.229	95250.08
23222.24	115694.5	61416.72	23208.35	1371.112	8391.673	38222.25	24925.02	13272.23	75861.17
25144.46	68777.83	50777.82	25133.35	3827.781	10758.34	25638.91	47277.82	17527.79	42166.7
21161.13	39833.37	41388.92	21152.79	7472.228	11980.57	20250.02	76222.28	20250.02	18763.9
11100.01	22863.91	25450.02	11094.45	11013.9	12336.12	14352.79	107916.8	21152.79	7677.784
4575.004	9811.119	10522.23	4575.004	13886.12	12513.9	5947.227	138305.7	19611.13	3069.447
2344.169	5388.893	4494.448	2343.335	15241.68	12663.9	2150.557	159166.8	17522.24	2509.446
0	107611.2	27244.47	0	60.91672	2969.447	27244.47	3138.891	2811.113	46444.48
0	116416.8	31166.69	0	91.05563	3144.447	31166.69	3786.114	2830.558	47638.93
2.166668	145639	47083.37	1.194445	112.8334	2988.891	47083.37	4888.893	3377.78	65666.72
1113.89	174333.5	66666.72	870.834	213.7779	3002.78	65805.61	5652.782	4313.892	88250.07
12455.57	177694.6	83250.07	10061.12	331.6669	4027.781	73194.5	8263.896	6180.561	95500.08
42388.92	154555.7	92972.3	33805.58	752.2228	6533.339	59166.71	16086.12	9500.008	91638.96
56250.05	121027.9	90611.18	43888.92	2099.724	9261.119	46722.26	31833.36	13455.57	72527.84
51555.6	85083.4	79777.84	40527.81	4788.893	10994.45	39222.25	56138.93	17266.68	44611.15
34222.25	55694.49	57027.82	27061.13	8150.007	12008.34	29972.25	88388.96	20238.91	24636.13
14302.79	33972.25	31305.58	12155.57	12166.68	12319.45	19155.57	122027.9	20563.91	13547.23
7188.895	24172.24	20338.91	7050.006	15408.35	12452.79	13288.9	147416.8	18538.9	9519.452
0	107611.2	27244.47	0	60.91672	2969.447	27244.47	3138.891	2811.113	46444.48
0	116416.8	31166.69	0	91.05563	3144.447	31166.69	3786.114	2830.558	47638.93
2.166668	145639	47083.37	1.194445	112.8334	2988.891	47083.37	4888.893	3377.78	65666.72
947.7785	175694.6	66555.61	489.1671	210.0002	2972.225	66083.39	5600.004	4250.003	88055.63
9838.897	186639	84222.29	5163.893	291.9447	3830.559	79055.62	7669.451	5947.227	95500.08
37777.81	176694.6	96000.08	19694.46	449.4448	5980.56	76305.62	13261.12	9158.341	94194.52
65027.83	149666.8	97750.08	33000.03	981.9452	8550.007	64750.05	24288.91	13172.23	81888.95
72694.5	124861.2	97611.19	35805.58	2158.057	10105.56	61805.61	41444.48	16402.79	60972.27
66750.05	110250.1	90722.29	32500.03	3927.781	11272.23	58222.27	65555.61	18602.79	50194.48
56611.16	93611.19	76222.28	27833.36	6386.116	11938.9	48388.93	91694.52	18944.46	43416.7
53222.26	92027.85	74000.06	25180.58	8105.562	12197.23	48805.59	110111.2	17461.13	41416.7
0	107611.2	27244.47	0	60.91672	2969.447	27244.47	3138.891	2811.113	46444.48
0	116416.8	31166.69	0	91.05563	3144.447	31166.69	3786.114	2830.558	47638.93
2.166668	145639	47083.37	1.194445	112.8334	2988.891	47083.37	4888.893	3377.78	65666.72
516.3893	184666.8	67472.28	29.94447	193.4446	2844.447	67444.5	5272.226	3825.003	88472.29
6222.227	214361.3	90944.52	261.5835	256.2502	3150.003	90694.52	6016.671	4433.337	97500.08
29944.47	226833.5	108583.4	1389.446	299.1669	4483.337	107194.5	8744.451	6172.227	98250.08
68583.39	216416.8	115666.8	4866.671	323.3336	6833.339	110777.9	14952.79	9786.119	90361.18
91500.07	195416.8	118861.2	9816.675	376.1114	8766.674	109027.9	26488.91	15261.12	77416.73
94166.74	176777.9	112416.8	13491.68	602.2227	10088.9	98916.75	43638.92	20830.57	73250.06
89888.96	155027.9	100277.9	13577.79	1272.779	11275.01	86694.51	66055.61	22838.91	65777.83

85361.18	146139	95527.85	10044.45	2094.446	12183.34	85500.07	86805.63	21111.13	57916.71
0	107611.2	27244.47	0	60.91672	2969.447	27244.47	3138.891	2811.113	46444.48
0	116416.8	31166.69	0	91.05563	3144.447	31166.69	3786.114	2830.558	47638.93
0	147666.8	43416.7	0	100.3612	2936.113	43416.7	4750.004	3369.447	66222.28
0	195889	60611.16	0	139.4446	2641.669	60611.16	4663.893	3416.669	89777.85
0	250833.5	87111.18	0	182.3335	2461.669	87111.18	4355.559	2983.336	98833.41
0	303889.1	105139	0	246.4724	2755.28	105139	5413.893	2442.78	100639
0	359444.7	117000.1	0	283.0558	3888.892	117000.1	8466.673	1726.39	94972.3
0	406667	128777.9	0	344.1669	5775.005	128777.9	13436.12	1426.668	82472.29
0	440278.1	132805.7	0	555.8338	7852.784	132805.7	21583.35	2684.724	77166.73
0	439167	127916.8	0	1148.056	9100.007	127916.8	34972.25	5347.227	67777.83
0	425000.3	124027.9	0	1907.502	9997.23	124027.9	51666.71	9141.674	54388.93

Primary energy (oil, CCS)	Primary energy (oil, no CCS)	Primary energy (other)	Primary energy (solar)	Primary energy (trad biomass)	Primary energy (wind)	Temperature	GDP per capita	Final energy (kWh)	Final energy per capita
0	48557.37	58.80305	4.572004	10553.69	103.8741	0.913386	8790.668	9.47E+13	14494.95
0	47700.82	68.65305	33.72603	11266.13	341.3472	0.989362	9890.766	1.02E+14	14739.31
60.15738	42964.06	99.15289	501.432	5952.919	1274.182	1.237116	13439	9.63E+13	12708.83
286.8897	23766.49	168.028	894.0568	2981.283	1580.485	1.466178	19332.18	7.63E+13	9470.211
531.0168	11579.33	515.5099	7272.867	2594.486	4574.711	1.557877	26606.49	8.03E+13	9569.036
408.322	8949.177	593.7719	13361.28	2290.657	8476.393	1.562219	34148.22	8.91E+13	10440.1
165.7848	7775.545	723.6147	18447.9	1829.056	8744.824	1.528371	41955.26	9.56E+13	11262.77
169.9748	6996.219	937.2774	22139.71	1358.427	6846.803	1.49271	50523.4	1E+14	12074.96
192.2911	6254.972	1165.719	24957.51	1036.26	7019.363	1.45588	59670.65	1.02E+14	12796.23
178.0199	5717.538	1361.028	25981.03	735.7428	8291.848	1.410488	69886.03	1.01E+14	13464.37
121.0128	5359.032	1570.177	25328.45	446.8262	7559.529	1.344853	81257.62	9.88E+13	14198.89
0	48557.37	58.80305	4.572004	10553.69	103.8741	0.913386	8790.668	9.47E+13	14494.95
0	47700.82	68.65305	33.72603	11266.13	341.3472	0.98863	9890.766	1.02E+14	14739.31
2.80E-14	47542.43	106.7054	443.5454	6417.03	1217.251	1.218161	13439	1.07E+14	14123.69
6.581449	41439.09	285.9605	1573.745	3881.47	2573.819	1.472536	19332.18	1.11E+14	13738.01
142.0418	33751.03	553.1743	5834.385	3474.336	4495.641	1.654554	26606.49	1.15E+14	13747.22
158.1949	30412.88	676.4897	13178.64	2877.05	6758.502	1.759317	34148.22	1.19E+14	13939.32
87.85974	27549.75	828.3998	19741.87	2267.683	8140.421	1.811741	41955.26	1.23E+14	14492.35
18.24386	23279.75	983.9516	24636.84	1702.658	8481.664	1.835215	50523.4	1.22E+14	14736.31
12.3367	15147.8	1173.584	27065.32	1261.484	8357.076	1.834751	59670.65	1.18E+14	14830.13
5.296621	10708.86	1382.894	26964.88	877.8849	7255.889	1.803641	69886.03	1.15E+14	15330.14
6.448497	10237.33	1553.563	31911.92	549.7346	7407.514	1.761081	81257.62	1.16E+14	16639.93
0	48557.37	58.80305	4.572004	10553.69	103.8741	0.913386	8790.668	9.47E+13	14494.95
0	47700.82	68.65305	33.72603	11266.13	341.3472	0.988462	9890.766	1.02E+14	14739.31
1.27E-18	48639.93	108.4494	441.6745	6524.672	1212.521	1.221132	13439	1.1E+14	14487.01
2.84E-06	44002.26	286.5663	1255.331	4207.931	2318.238	1.492611	19332.18	1.2E+14	14846.83
0.000192	38148.14	567.6949	4074.986	3976.664	4427.535	1.714407	26606.49	1.31E+14	15630.14
0.000563	36473.22	747.4342	10783.32	3418.961	7301.795	1.8992	34148.22	1.4E+14	16434.75
1.066966	33878.03	915.1774	18352.01	2730.274	8285.22	2.03953	41955.26	1.45E+14	17098.98
2.158196	28697.22	1040.737	25927.05	2036.958	9159.185	2.150535	50523.4	1.42E+14	17098.66
2.231133	19927.32	1184.507	29919.19	1462.251	9870.641	2.219817	59670.65	1.32E+14	16580.28
3.998687	12097.56	1352.781	29902.09	967.5258	9288.168	2.230802	69886.03	1.24E+14	16496.4
4.567112	9359.749	1559.835	30937.02	563.2296	8361.768	2.193107	81257.62	1.21E+14	17334.19
0	48557.37	58.80305	4.572004	10553.69	103.8741	0.913386	8790.668	9.47E+13	14494.95
0	47700.82	68.65305	33.72603	11266.13	341.3472	0.988451	9890.766	1.02E+14	14739.31
5.01E-18	48604.62	108.4665	441.0525	6525.575	1211.584	1.221551	13439	1.1E+14	14485.58
0.016411	44372.04	286.6211	1190.635	4279.289	2230.372	1.494779	19332.18	1.21E+14	15053.8
0.016361	39375.7	568.5977	3408.095	4186.184	4147.916	1.725589	26606.49	1.37E+14	16355.87
0.010709	38643.75	811.5423	8718.397	3688.761	6919.92	1.936466	34148.22	1.5E+14	17615.63

0.000514	36643.84	993.8858	14851.76	2989.461	8118.537	2.137401	41955.26	1.57E+14	18526.63
0.001145	31948.91	1143.362	23541.75	2290.96	8572.276	2.325398	50523.4	1.57E+14	18865.66
0.03435	23651.34	1287.574	30085.7	1721.051	9698.682	2.476998	59670.65	1.49E+14	18737.05
5.712482	16635.64	1432.233	32544.68	1168.176	10352.47	2.585335	69886.03	1.39E+14	18488.77
4.87359	12434.35	1583.128	33286.2	669.982	9921.527	2.652743	81257.62	1.3E+14	18704.06
0	48557.37	58.80305	4.572004	10553.69	103.8741	0.913386	8790.668	9.47E+13	14494.95
0	47700.82	68.65305	33.72603	11266.13	341.3472	0.988441	9890.766	1.02E+14	14739.31
0	48637.37	108.5403	440.7903	6526.647	1211.108	1.222835	13439	1.1E+14	14492.14
0	44336.95	286.6319	1174.396	4274.045	2203.281	1.505786	19332.18	1.22E+14	15095.51
0	39617.92	568.6196	3267.944	4230.42	4077.902	1.770743	26606.49	1.39E+14	16561.01
0	39270.56	823.0454	8177.612	3744.603	6768.503	2.022057	34148.22	1.52E+14	17831.44
0	37742.73	1013.104	13644.48	3068.519	7888.962	2.246411	41955.26	1.61E+14	19011.02
0	33786.67	1190.54	21189.27	2419.758	8296.056	2.46035	50523.4	1.65E+14	19916.95
0	25938.95	1371.212	28926.88	1892.147	9116.941	2.668723	59670.65	1.63E+14	20430.42
0	19315.21	1522.214	32575.96	1324.84	9191.266	2.856211	69886.03	1.56E+14	20772.72
0	15063.13	1691.641	32737.33	778.1809	8833.68	3.017736	81257.62	1.47E+14	21091.25
	47939.21	0	85.55562	8144.784	106.389	0.913386	8693.168	8.97E+13	13800.29
	48078.37	0	688.3339	8473.087	460.2781	0.989048	9829.892	1E+14	14631.6
	57878.66	0	2891.391	7867.229	1856.668	1.241434	13256.35	1.22E+14	16013.15
	46715.59	0	7355.839	7269.714	6559.172	1.502207	17087.47	1.18E+14	14249.94
	27713.63	0	12300.57	6240.838	13941.96	1.627379	20595.87	1.17E+14	13282.93
	9306.119	0	17775.85	5005.129	19836.68	1.64476	24349.11	1.22E+14	13272.59
	3833.336	0	22417.52	3635.828	25383.35	1.616748	28659.24	1.32E+14	14012.51
	2894.725	0	27799.74	2247.521	32781.97	1.569317	33973.31	1.41E+14	14882.27
	2210.28	0	32533.64	750.47	41065.03	1.503767	40183.39	1.5E+14	15984.42
	1321.112	0	39653.92	0	49257.54	1.424558	47372.05	1.6E+14	17299.41
	790.834	0	50274.48	0	59210.33	1.336877	55863.78	1.72E+14	19012.21
	47954.21	0	85.55562	8144.784	107.5001	0.913386	8693.168	8.97E+13	13798.49
	48088.37	0	688.6117	8473.087	461.3893	0.989073	9831.668	1.01E+14	14636.17
	57598.38	0	2953.891	7867.229	1853.057	1.241272	13280.54	1.22E+14	16005.05
	57046.16	0	6151.672	7269.714	4671.393	1.492433	17243.16	1.33E+14	16055.27
	53204.76	0	10017.79	6240.838	7874.729	1.696799	20992.51	1.4E+14	15943.01
	39233.09	0	13806.96	5005.129	11325.01	1.809846	24922.56	1.46E+14	15913.59
	26549.74	0	17708.63	3635.828	15277.79	1.853236	29466.69	1.56E+14	16581.79
	11466.95	0	23205.57	2247.521	20407.79	1.861529	34987.38	1.65E+14	17460.44
	3722.225	0	28758.08	750.47	29787.8	1.844434	41463.49	1.77E+14	18763.24
	1458.335	0	35318.08	0	42954.76	1.807019	49101.35	1.88E+14	20269.26
	663.3339	0	43891.98	0	58303.94	1.754633	58093.56	2.01E+14	22273.83
	47954.21	0	85.55562	8144.784	107.5001	0.913386	8693.168	8.97E+13	13798.49
	48088.37	0	688.6117	8473.087	461.3893	0.989049	9832.498	1.01E+14	14636.17
	57669.21	0	2909.447	7867.229	1842.224	1.242073	13290.67	1.22E+14	16006.44
	61837.27	0	5904.727	7269.714	3685.003	1.492368	17295.13	1.39E+14	16778.69
	62512.55	0	9570.841	6240.838	6665.005	1.737479	21097.86	1.52E+14	17331.09
	57249.77	0	12851.4	5005.129	10070.84	1.918756	25104.57	1.63E+14	17725.62
	44621.42	0	16462.79	3635.828	13736.96	2.050532	29688.43	1.7E+14	18074.08
	34438.92	0	19806.96	2247.521	16833.35	2.14427	35337.86	1.82E+14	19247.17
	21323.63	0	23394.19	750.47	20825.57	2.200498	41933.38	1.95E+14	20687.26

10363.34	0	29121.13	0	29874.47	2.220768	49697.79	2.06E+14	22281.52
5146.671	0	35426.97	0	42077.26	2.212415	58890.66	2.21E+14	24501.91
47954.21	0	85.55562	8144.784	107.5001	0.913386	8693.168	8.97E+13	13798.49
48088.37	0	688.6117	8473.087	461.3893	0.989027	9832.688	1.01E+14	14636.17
57663.66	0	2887.225	7867.229	1665.557	1.242266	13297.25	1.22E+14	16035.34
61943.94	0	5756.116	7269.714	3625.558	1.485988	17310.45	1.42E+14	17128.72
64877	0	9186.396	6240.838	6074.449	1.743192	21137.41	1.58E+14	18036.13
64183.66	0	12298.07	5005.129	8940.285	1.966494	25174.9	1.72E+14	18710.91
55193.66	0	14952.51	3635.828	13221.12	2.154152	29810.93	1.81E+14	19281.69
42633.65	0	18218.9	2247.521	16448.9	2.317638	35497.94	1.92E+14	20346.14
32180.3	0	21101.68	750.47	18918.63	2.458626	42145.93	2.07E+14	21999.4
21713.07	0	25868.08	0	21806.13	2.566724	49988.71	2.22E+14	23943.19
14348.07	0	29749.47	0	28912.52	2.629087	59259.4	2.38E+14	26302.13
47954.21	0	85.55562	8144.784	107.5001	0.913386	8693.168	8.97E+13	13798.49
48088.37	0	688.6117	8473.087	461.3893	0.989018	9833.081	1.01E+14	14636.17
57738.94	0	2887.225	7867.229	1630.279	1.242303	13300.46	1.22E+14	16042.31
62636.99	0	5756.949	7269.714	3245.28	1.481852	17313.4	1.43E+14	17333.95
66032.55	0	8865.007	6240.838	5197.226	1.754337	21154.52	1.62E+14	18398.09
67171.44	0	11336.68	5005.129	7971.951	2.025425	25215.99	1.77E+14	19265.46
61087.27	0	14085.84	3635.828	11746.4	2.286602	29871.88	1.9E+14	20192.99
55349.49	0	16575.29	2247.521	15788.9	2.545365	35598.11	2.02E+14	21353.17
60897.55	0	19317.79	750.47	19493.35	2.786019	42312.35	2.2E+14	23365.1
67729.78	0	22671.96	0	22352.24	3.011456	50267.8	2.4E+14	25929.13
71854.22	0	25762.8	0	23448.35	3.229339	59608.05	2.61E+14	28907.84
47947.82	0	85.55562	8144.784	107.5001	0.913386	8693.168	8.97E+13	13798.37
48088.93	0	688.6117	8473.087	461.3893	0.988977	9833.255	1.01E+14	14636.17
57572.82	0	2887.225	7867.229	1528.89	1.241407	13301.95	1.22E+14	16070.08
62710.61	0	5698.338	7269.714	2849.447	1.48262	17316.62	1.44E+14	17459.05
66860.89	0	8644.729	6240.838	4630.281	1.761503	21162.18	1.63E+14	18561.46
68357.83	0	11085.29	5005.129	6837.505	2.052806	25226.03	1.79E+14	19507.88
63125.61	0	13622.79	3635.828	9982.23	2.356264	29890.72	1.93E+14	20550.28
57784.77	0	15812.51	2247.521	13579.46	2.681335	35619.41	2.07E+14	21910.29
64650.33	0	17291.96	750.47	15629.73	3.023154	42360.71	2.26E+14	24069.05
75016.45	0	19151.4	0	18958.07	3.387957	50340.29	2.48E+14	26762.14
82947.01	0	21931.41	0	23475.02	3.76329	59710.73	2.71E+14	29948.99
0	45625.45	9.666674	2.833336	102.139	0.913386	8431.4	9.28E+13	14300.21
0	48948.01	9.555563	26.00002	125.139	0.988307	9420.344	1E+14	14582.31
0	59300.08	10.55556	58.66671	307.7502	1.229122	12652.99	1.23E+14	15953.58
0	63841.58	11.61112	295.4725	1256.084	1.515949	15275.35	1.4E+14	16423.37
2839.169	57210.21	12.47223	1293.557	3202.503	1.828829	16242.24	1.28E+14	13872.38
9538.369	47747.23	13.02779	2695.391	4839.754	1.989656	16718.17	1.33E+14	13375.45
13952.48	38462.45	13.36112	4021.864	7187.422	2.07976	17059.94	1.37E+14	12957.29
13124.57	31141.52	13.58334	5805.755	10967.65	2.146508	17519.24	1.38E+14	12374.22
11999.59	24922.8	13.55557	8530.868	15267.26	2.188886	18004.77	1.39E+14	11976.57
10429.04	19901.52	13.3889	11724.87	20629.1	2.210887	18511.78	1.43E+14	11793.86
8893.979	16404.51	13.19446	15502.9	26159.83	2.211311	19205.9	1.49E+14	11830.15
0	45625.45	9.666674	2.833336	102.139	0.913386	8431.4	9.28E+13	14300.21

0	48948.01	9.555563	26.00002	125.139	0.988307	9420.344	1E+14	14582.31
0	59300.08	10.55556	58.66671	307.7502	1.230334	12652.99	1.23E+14	15953.58
0	65969.44	11.11112	223.9446	901.4174	1.522074	15293.9	1.43E+14	16839.06
0	66977.28	11.02779	734.5006	1900.113	1.841247	16482.92	1.43E+14	15469.7
1400.501	63122.61	11.47223	1635.668	3047.502	2.06258	17044.57	1.47E+14	14776.18
4994.615	52414.1	11.75001	2795.724	5001.226	2.236536	17322.18	1.47E+14	13882.77
9734.23	44945.67	11.94445	3711.781	6769.117	2.362402	17897.66	1.51E+14	13603.94
12228.01	38229.92	11.91668	4841.782	9145.98	2.465828	18538.32	1.55E+14	13325.18
11813.87	33678.78	11.77779	6627.644	12537.45	2.554043	19167.94	1.58E+14	13058.82
11125.84	28463.88	11.58334	9305.813	17063.1	2.617403	19867.22	1.62E+14	12800.22
0	45625.45	9.666674	2.833336	102.139	0.913386	8431.4	9.28E+13	14300.21
0	48948.01	9.555563	26.00002	125.139	0.988307	9420.344	1E+14	14582.31
0	59300.08	10.55556	58.66671	307.7502	1.230793	12652.99	1.23E+14	15953.58
0	66107.44	10.94445	219.6946	880.3896	1.52418	15295.08	1.44E+14	16871.54
0	68577.36	10.6389	619.2505	1630.029	1.844651	16567.18	1.5E+14	16176.95
0	67318.75	10.52779	1255.807	2375.53	2.099352	17224.24	1.56E+14	15700.25
0	64074.55	10.77779	1801.168	3259.947	2.333273	17723.15	1.64E+14	15512.2
218.4446	60965.69	10.97223	2421.446	4383.726	2.58092	18357.12	1.69E+14	15156.9
1342.112	56607.27	10.94445	3278.308	5957.449	2.806649	19026.74	1.73E+14	14846.58
1963.613	53646.29	10.80556	4154.809	7680.867	3.005281	19785.93	1.8E+14	14820.66
3117.808	49515.18	10.6389	5145.032	9792.952	3.183591	20724.26	1.88E+14	14877.41
	45625.45	9.666674	2.833336	102.139	0.913386	8431.4	9.28E+13	14300.21
	49061.57	9.555563	25.83335	125.4723	0.988055	9421.015	1E+14	14608.01
	60254.49	10.55556	42.50003	165.2501	1.225753	12659.11	1.25E+14	16183.31
	67431.47	11.61112	72.63895	217.5002	1.523809	15315.63	1.46E+14	17151.13
	70758.14	12.47223	117.9723	277.1669	1.864192	16697.99	1.61E+14	17409.83
	69415.5	13.02779	178.6946	330.4169	2.202509	17440.16	1.72E+14	17279.38
	66032.03	13.36112	237.2502	444.0281	2.550932	17975.93	1.8E+14	17050.6
	63575.13	13.58334	305.528	578.7782	2.911519	18700.1	1.89E+14	16958.08
	60997.97	13.55557	409.3614	778.9728	3.284348	19489.89	1.97E+14	16920.96
	59563.41	13.3889	529.1671	1010.279	3.672423	20362.15	2.06E+14	17017.75
	56900.82	13.19446	678.9172	1303.029	4.0711	21415.38	2.16E+14	17145.87
0	48910.83		33.47359	8491.139	341.7173	0.98868	9706.811	1.09E+14
44.25278	52687.65		487.8533	9495.258	1594.598	1.232684	13091.2	1.32E+14
340.1738	49556.48		1612.895	11071.58	5149.813	1.507354	17134.43	1.39E+14
461.392	46490.8		3529.754	11745.65	7933.148	1.68673	20809.4	1.49E+14
538.4816	41459.17		6318.113	12244.63	9875.47	1.794301	23945.28	1.54E+14
479.2541	31710.23		9835.376	12604.08	10096.38	1.865045	26820.64	1.56E+14
401.9085	22746.68		13577.58	12733.68	11028.85	1.909638	29732.64	1.57E+14
323.8311	14414.7		17430.34	12654.5	12531.71	1.928478	32446.68	1.56E+14
211.6517	8077.164		22819.56	12119.17	14954.36	1.892715	35121.67	1.56E+14
84.28006	3706.808		27581.92	10825.39	16058.59	1.799397	37893.19	1.58E+14
0	48910.83		33.47343	8491.139	341.7174	0.98868	9706.811	1.09E+14
44.2492	52687.65		487.8533	9495.258	1594.598	1.231585	13089.16	1.32E+14
141.3829	52451.51		1279.284	10680.94	3632.848	1.483902	17103.95	1.45E+14

219.7695	51549.08	2931.221	11247.29	6292.577	1.712703	20811.18	1.57E+14	17904.78
327.6789	49222.03	5494.082	11662.09	8486.905	1.895201	23955.95	1.63E+14	17785.64
445.8955	42606.99	8860.824	11947.39	9692.804	2.019821	26833.11	1.65E+14	17568.28
439.4754	35920.47	12579.8	12026.73	10174.95	2.110105	29747.96	1.65E+14	17406.2
403.9485	26947.73	15914.75	11970.65	10852.05	2.17456	32453.26	1.63E+14	17221.93
341.9064	17762.59	20195.87	11594.09	12688.16	2.206742	35137.43	1.61E+14	17102.14
236.0736	11405.18	25740.25	10926.78	14735.23	2.186048	37890.07	1.59E+14	17142.65
0	48910.83	33.47343	8491.139	341.7174	0.98868	9706.811	1.09E+14	15865.01
44.22547	52687.68	487.8533	9495.258	1594.598	1.231278	13089.16	1.32E+14	17258.77
91.49143	53362.14	1158.853	10458.99	3148.892	1.480864	17103.95	1.49E+14	18020.88
127.5699	53260.43	2531.949	10967.67	5135.303	1.722219	20811.18	1.62E+14	18453.81
184.5796	52336.18	4779.242	11327.55	7086.068	1.941254	23955.95	1.68E+14	18413.71
317.6923	48196.36	8038.288	11559.2	8937.223	2.117408	26833.11	1.71E+14	18244.94
393.4593	44213.97	11758.94	11614.4	9917.334	2.250108	29747.96	1.71E+14	18065.98
246.2743	43760.97	14010.53	11158.75	9330.96	2.36523	32453.26	1.74E+14	18361.03
273.3348	43157.02	16120.34	10208.16	9155.227	2.450691	35137.43	1.75E+14	18588.92
284.7225	39645.66	19593.02	9396.814	10152.73	2.516387	37890.07	1.73E+14	18662.7
0	48910.83	33.47343	8491.139	341.7174	0.98868	9706.811	1.09E+14	15865.01
44.00961	52687.89	487.8533	9495.258	1594.598	1.231	13089.16	1.32E+14	17258.77
49.85947	53597.08	1006.801	10061.38	2737.774	1.490755	17103.95	1.55E+14	18733.22
50.33079	54181.64	2032.219	10427.04	3961.883	1.777343	20811.18	1.7E+14	19447.44
49.23971	54852.33	3510.729	10582.59	4533.673	2.053811	23955.95	1.8E+14	19715.81
65.56506	53868.14	5512.246	10501.48	5230.114	2.311553	26833.11	1.86E+14	19884.74
71.13257	55783.91	7717.294	10245.25	5706.592	2.560291	29747.96	1.9E+14	20008.24
94.14153	56888.41	10418.8	9820.371	7086.295	2.802207	32453.26	1.89E+14	20001.29
128.0455	56226.55	13768.81	9176.197	8670.85	3.004306	35137.43	1.87E+14	19933.11
162.9043	53439.87	18262.63	8539.322	10262.53	3.156524	37890.07	1.85E+14	19860.6
0	47349.72	4.540956	7938.579	103.9778	0.913386	8716.302	9.97E+13	15328.51
0	48910.83	33.47343	8491.139	341.7174	0.988562	9706.811	1.09E+14	15865.01
0	53132.06	455.4946	9405.006	1442.737	1.237213	13089.16	1.34E+14	17521.86
0	52381.21	974.5734	9981.251	2608.658	1.532875	17103.95	1.56E+14	18840.48
0	52064.62	1943.509	10313.45	3744.478	1.873893	20811.18	1.72E+14	19606.37
0	52238.01	3306.326	10339.7	4285.926	2.216306	23955.95	1.82E+14	19935.42
0	50679.03	5114.856	10182.43	4743.325	2.546151	26833.11	1.89E+14	20204.39
0	52747.69	7002.736	9828.849	4959.187	2.87451	29747.96	1.94E+14	20468.74
0	54759.92	9030.877	9182.252	5825.461	3.200995	32453.26	1.96E+14	20655.41
0	55866.81	11028.05	8450.834	6581.459	3.494213	35137.43	1.96E+14	20850.96
0	56206.87	13167.79	7754.914	7220.4	3.758289	37890.07	1.96E+14	21127.42
46444.48		1.722224	9186.118	106.9445	0.913386	8714.835	9.19E+13	14121.63
47638.93		65.72227	9397.23	483.8893	0.989287	9801.276	9.9E+13	14360.32
65666.72		458.6115	6433.338	1328.334	1.259486	13493.11	1.25E+14	16581.35
88833.4		931.9452	2913.891	2975.002	1.536892	20213.56	1.37E+14	17027.44
69000.06		5055.56	809.7229	7283.339	1.729645	29346.66	1.33E+14	15804.55
32166.69		18077.79	0	13405.57	1.809724	39445.16	1.42E+14	16571.49
8133.34		36555.58	0	19175.02	1.777239	51298.17	1.5E+14	17496.55

3744.447	54222.27	0	23825.02	1.689111	66217.33	1.71E+14	20196.96
3030.558	71250.06	0	28111.13	1.589518	83719.51	1.91E+14	23313.03
2632.224	87777.85	0	32472.25	1.487402	104584.3	2.1E+14	26791.69
2409.169	102861.2	0	34361.14	1.374447	130183.1	2.25E+14	30467.07
46444.48	1.722224	9186.118	106.9445	0.913386	8714.835	9.19E+13	14121.63
47638.93	65.72227	9397.23	483.8893	0.989291	9801.276	9.9E+13	14360.32
65666.72	458.6115	6433.338	1328.334	1.259341	13493.11	1.25E+14	16581.35
92777.85	515.2782	2913.891	2257.78	1.547275	20449.47	1.5E+14	18586.36
95250.08	1408.612	809.7229	4533.337	1.795001	30286.8	1.61E+14	19126.78
75861.17	6366.672	0	8797.229	1.96702	40983.8	1.73E+14	20139.63
42166.7	18850.02	0	13844.46	2.048924	53091.16	1.76E+14	20446.06
18763.9	37555.59	0	19216.68	2.058	68203.85	1.85E+14	21855.68
7677.784	59833.38	0	24741.69	2.017137	85768.29	1.99E+14	24237.82
3069.447	81166.73	0	30722.25	1.933609	106448.7	2.14E+14	27359.24
2509.446	97944.52	0	33305.58	1.823153	132230.5	2.3E+14	31156.33
46444.48	1.722224	9186.118	106.9445	0.913386	8714.835	9.19E+13	14121.63
47638.93	65.72227	9397.23	483.8893	0.989292	9801.276	9.9E+13	14360.32
65666.72	458.6115	6433.338	1328.334	1.259449	13493.11	1.25E+14	16581.35
88250.07	445.2781	2913.891	1991.113	1.554135	20461.88	1.51E+14	18769.16
95500.08	602.7783	809.7229	3300.003	1.838677	30441.51	1.69E+14	20072.21
91638.96	2442.78	0	6355.561	2.057854	41426.74	1.87E+14	21790.95
72527.84	9991.675	0	10480.56	2.201463	53859.59	1.95E+14	22667.9
44611.15	25047.24	0	15316.68	2.298636	69055.22	1.99E+14	23530.82
24636.13	46944.48	0	21272.24	2.341335	86987.8	2.09E+14	25528.48
13547.23	69722.28	0	27833.36	2.322814	108172.6	2.22E+14	28313.42
9519.452	88527.85	0	31027.8	2.252036	133789.8	2.33E+14	31574.41
46444.48	1.722224	9186.118	106.9445	0.913386	8714.835	9.19E+13	14121.63
47638.93	65.72227	9397.23	483.8893	0.989292	9801.276	9.9E+13	14360.32
65666.72	458.6115	6433.338	1328.334	1.259498	13493.11	1.25E+14	16581.35
88055.63	436.3892	2913.891	1982.502	1.555131	20474.3	1.52E+14	18882.97
95500.08	428.3337	809.7229	3119.447	1.856649	30512.91	1.73E+14	20594.51
94194.52	1224.723	0	5608.338	2.108722	41659.87	1.96E+14	22898.31
81888.95	5847.227	0	8911.118	2.291695	54325.3	2.11E+14	24527.52
60972.27	16250.01	0	12938.9	2.438038	69705.57	2.19E+14	25866.17
50194.48	32500.03	0	17861.13	2.556399	88146.34	2.33E+14	28434.98
43416.7	50027.82	0	23358.35	2.637877	110228.6	2.44E+14	31140.51
41416.7	63555.61	0	26236.13	2.683349	137220.3	2.58E+14	34986.85
46444.48	1.722224	9186.118	106.9445	0.913386	8714.835	9.19E+13	14121.63
47638.93	65.72227	9397.23	483.8893	0.989292	9801.276	9.9E+13	14360.32
65666.72	458.6115	6433.338	1328.334	1.259277	13493.11	1.25E+14	16581.35
88472.29	433.6115	2913.891	1798.613	1.554898	20536.38	1.56E+14	19389.97
97500.08	326.1114	809.7229	2281.668	1.8858	30739.02	1.85E+14	21976.3
98250.08	294.7225	0	3666.67	2.216687	42091.15	2.13E+14	24853.99
90361.18	1944.168	0	5850.005	2.513596	54977.3	2.34E+14	27211.83
77416.73	7647.228	0	9700.008	2.781248	70509.64	2.48E+14	29328.13
73250.06	18188.9	0	14755.57	3.009628	88914.63	2.61E+14	31869.94
65777.83	33194.47	0	20319.46	3.189769	111148	2.68E+14	34283.29

57916.71	49305.6	0	23238.91	3.327655	138305.1	2.8E+14	37928.47
46444.48	1.722224	9186.118	106.9445	0.913386	8714.835	9.19E+13	14121.63
47638.93	65.72227	9397.23	483.8893	0.989124	9801.276	9.9E+13	14360.32
66222.28	458.6115	6433.338	1253.89	1.265801	13493.11	1.25E+14	16570.31
89777.85	433.6115	2913.891	1448.057	1.60296	20586.04	1.6E+14	19841.78
98833.41	313.3336	809.7229	1398.612	2.01275	30965.13	1.98E+14	23539.89
100639	43.50003	0	2367.502	2.48049	42510.78	2.33E+14	27123.75
94972.3	103.4445	0	4191.67	2.975504	55687.51	2.61E+14	30413.6
82472.29	791.1117	0	6525.005	3.503795	71632.97	2.85E+14	33699.92
77166.73	3691.67	0	9486.119	4.0499	90317.07	3.08E+14	37533.91
67777.83	11136.12	0	13575.01	4.575695	112667.6	3.17E+14	40473.08
54388.93	22469.46	0	17286.12	5.051967	139796.6	3.24E+14	43954.84

Primary	CO2	Methane	Nitrous	Primary	Primary	Primary	Primary	Primary	Primary
energy per	emissions	emisison	oxide	energy (%)	energy (%)	energy (%)	energy (%)	energy (%)	energy (%)
capita	per capita	per capita	emissions	energy (%,	energy (%,	energy (%,	energy (%,	energy (%,	energy (%,
			per capita	fossil)	fossil CCS)	coal)	coal CCS)	gas)	gas CCS)
19524.63	5.078605	0.048755	0.001402	85.8852	0	25.5937	0	22.20923	0
20301.51	5.127111	0.050256	0.00142	84.90192	0	28.65972	0	22.29699	0
17717.18	4.383361	0.039581	0.001224	84.33913	0.425782	25.72294	0.0899	26.56291	0.291064
13663.77	2.228741	0.026716	0.000942	71.83293	6.296393	14.95157	0.865161	35.04571	5.170794
13232.66	0.764588	0.021328	0.000915	55.46905	21.26424	7.46109	2.601379	37.09829	18.18449
14037.73	0.113479	0.017985	0.000888	47.67697	26.01147	5.713096	3.694534	34.1496	21.97595
15129.18	-0.1943	0.016982	0.000895	42.77815	26.40641	5.394406	4.292189	31.20274	21.98519
16563.48	-0.49849	0.016371	0.000935	39.3019	26.79873	5.33272	4.468459	28.75587	22.20662
17609.08	-0.92505	0.015779	0.001004	31.82977	21.5354	4.602757	3.914173	22.63162	17.48417
18337.22	-1.40707	0.015589	0.001081	24.39037	15.46699	3.541162	2.966763	16.5684	12.37096
19559.95	-2.061	0.015766	0.001193	18.57704	10.19158	2.392365	1.923926	12.15813	8.178738
19524.63	5.078605	0.048755	0.001402	85.8852	0	25.5937	0	22.20923	0
20301.51	5.12711	0.050256	0.00142	84.90192	0	28.65972	0	22.29697	0
19967.42	5.067219	0.041555	0.001244	86.67887	1.98E-12	27.953	1.88E-12	27.29812	1.04E-13
19196.77	4.20878	0.031936	0.001027	83.85839	1.207527	23.7657	0.863042	33.31263	0.340232
18318.05	3.088028	0.02624	0.000923	76.03586	6.599247	17.5393	3.795309	36.44019	2.711502
17981.27	2.078768	0.022318	0.00089	66.93619	9.614476	12.08633	5.481054	34.91947	4.030289
18712.69	1.244181	0.020648	0.000894	57.22772	11.84035	9.448647	7.366728	30.38724	4.418339
19065.28	0.576608	0.018936	0.000929	48.44177	12.58529	9.080738	7.844675	24.63614	4.729088
19815.65	-0.36673	0.017005	0.001007	37.86934	12.62934	7.966911	7.001938	20.30004	5.619593
21075.93	-1.07827	0.017075	0.001137	31.57092	12.06249	7.114524	6.336706	17.6877	5.722439
22476.93	-1.19968	0.017293	0.001201	29.81389	10.84192	5.331619	4.752449	17.9323	6.085344
19524.63	5.078605	0.048755	0.001402	85.8852	0	25.5937	0	22.20923	0
20301.93	5.12711	0.050256	0.00142	84.90014	0	28.65912	0	22.29651	0
20553.5	5.232081	0.046785	0.001324	86.8736	5.38E-15	28.28641	5.09E-15	27.35077	2.83E-16
21067.54	4.881134	0.038363	0.001189	85.24992	0.001495	26.43555	0.001458	32.9071	3.62E-05
21332.92	4.463485	0.032066	0.001051	80.59308	0.031995	22.68287	0.029685	36.59325	0.00231
21569.71	3.86229	0.028071	0.000973	74.97745	0.334773	17.91062	0.287994	37.24447	0.046778
22051.25	3.291922	0.025273	0.000937	68.91432	1.63229	14.53203	1.265642	36.29057	0.366078
21610.68	2.387444	0.021588	0.000925	59.73585	4.707122	12.63624	3.07292	31.09737	1.632998
21261.67	1.145089	0.019413	0.000965	47.74472	7.888701	10.74744	5.290644	25.23249	2.596739
22085.02	-0.30297	0.017923	0.001095	34.63062	9.361215	8.675069	6.192595	18.65967	3.166208
23716.02	-0.95077	0.018756	0.001252	29.20391	8.904856	7.362072	6.085171	16.16704	2.816918
19524.63	5.078605	0.048755	0.001402	85.8852	0	25.5937	0	22.20923	0
20301.93	5.12711	0.050256	0.00142	84.90016	0	28.65913	0	22.29651	0
20565.03	5.261294	0.047231	0.00133	86.78872	4.93E-15	28.30947	4.67E-15	27.283	2.59E-16
21451.67	5.080428	0.041098	0.001239	85.6733	0.000802	27.15026	0.000766	32.86587	2.6E-05
22693.95	4.946927	0.037181	0.001174	82.02639	0.005216	25.36435	0.004811	35.97872	0.000396
23896.6	4.691515	0.034935	0.001145	77.92376	0.012814	22.91746	0.012273	36.04931	0.000535

24784.54	4.44347	0.031276	0.001085	73.92138	0.037251	21.15331	0.036688	35.35797	0.000563
24770.3	3.89483	0.027578	0.001026	66.79813	0.096172	18.23172	0.095374	33.0246	0.000797
24198.91	3.069469	0.02403	0.001001	57.52143	0.879374	14.57179	0.545675	30.68246	0.333682
23761.26	2.304477	0.02159	0.001038	49.26531	2.20604	11.8361	1.242314	28.10413	0.960525
24076.97	1.592277	0.020051	0.001101	42.75111	3.170374	9.3546	1.740583	25.97131	1.426882
19524.63	5.078605	0.048755	0.001402	85.8852	0	25.5937	0	22.20923	0
20301.93	5.12711	0.050256	0.00142	84.90016	0	28.65913	0	22.29651	0
20574.22	5.288866	0.048262	0.001346	86.78001	0	28.31765	0	27.25905	0
21526.92	5.290692	0.047282	0.001304	85.33983	0	27.30022	0	32.49234	0
23062.08	5.218707	0.046473	0.001266	82.15983	0	25.93932	0	35.74214	0
24364.97	4.976819	0.044488	0.001231	78.94242	0	24.11625	0	35.93204	0
25793.32	4.898854	0.04265	0.001209	75.73474	0	23.43217	0	35.0717	0
26888.87	4.725602	0.040811	0.001224	70.4649	0	22.67572	0	32.64835	0
27226.66	4.191122	0.038276	0.001257	62.91521	0	20.24979	0	30.70788	0
27558.41	3.810477	0.036389	0.001308	57.80858	0	18.32829	0	30.14819	0
27972.08	3.53736	0.035385	0.001354	55.2398	0	16.49562	0	31.00479	0
19837.6	5.807548	0.0514	0.001274	84.91311	0	26.11692	0	21.63588	0
20226	5.87028	0.047442	0.001274	83.72467	0	27.99962	0	21.11135	0
20972.88	5.37774	0.043311	0.001257	81.22756	0	23.73844	0	21.23108	0
17118.6	2.860464	0.032396	0.001183	67.4325	4.408625	6.919422	1.929056	27.48306	2.479569
16197.9	1.31148	0.025028	0.001049	51.38115	14.08495	4.673125	4.325544	27.23703	9.759406
16658.85	0.412136	0.020944	0.000894	36.30194	16.5952	6.967601	6.94105	23.24182	9.654148
17923.75	-0.16097	0.018015	0.00079	23.63777	10.79825	5.310361	5.301444	16.0485	5.496803
19145.07	-0.6916	0.015515	0.000693	14.55226	4.592744	2.381139	2.376229	10.57229	2.216515
20552.73	-1.12773	0.013548	0.00065	9.801147	1.142749	0.566059	0.563185	8.091908	0.579564
22349.3	-1.34114	0.012211	0.000609	7.468145	0.10409	0.105164	0.103553	6.724205	0.000537
24673.24	-1.44467	0.01143	0.000581	6.938247	0.005235	0.005858	0.004986	6.57753	0.000249
19839.27	5.808099	0.051402	0.001274	84.91416	0	26.11645	0	21.6289	0
20264.14	5.867487	0.047547	0.001275	83.54592	0	27.89062	0	21.09956	0
20949.09	5.341694	0.043452	0.001259	80.84266	0.035017	23.55409	0.010801	21.16513	0.024215
19768.15	4.180785	0.037268	0.001244	75.02989	2.406257	14.10215	1.038154	25.99959	1.368104
19549.49	2.993656	0.030676	0.001178	69.52464	8.926605	7.605499	3.146077	30.9472	5.780528
19995.75	1.781045	0.026622	0.001082	62.34972	20.9195	8.423341	7.060989	32.52767	13.85851
21300.59	0.985418	0.024079	0.001006	55.53153	25.86842	12.1197	11.45229	30.13029	14.41614
22991.36	0.212573	0.023019	0.000926	46.94513	26.56161	16.5075	16.30079	25.16369	10.26082
24565.41	-0.43007	0.021246	0.000833	37.71052	22.35211	15.91903	15.91663	20.18078	6.435479
26371.37	-0.70194	0.018998	0.000785	28.60162	16.11057	12.71904	12.71768	15.285	3.392898
28546.94	-0.92525	0.017257	0.000739	21.14307	10.26392	9.335611	9.334857	11.5502	0.929058
19839.27	5.808101	0.051402	0.001274	84.91416	0	26.11645	0	21.6289	0
20264.67	5.867481	0.047547	0.001275	83.54375	0	27.8899	0	21.09901	0
20969.96	5.476874	0.043814	0.001265	81.14733	0.022451	23.62445	0.009572	21.39102	0.012879
21175.84	5.087341	0.040795	0.001275	79.59215	0.523152	19.25485	0.511403	24.99254	0.011749
21313.19	4.34951	0.034318	0.001242	76.07344	2.31722	12.66306	1.953685	30.03146	0.363535
21961.01	3.556718	0.03027	0.001187	71.68571	5.691221	9.7603	4.160677	33.49427	1.530543
22820.67	2.589604	0.027381	0.001119	65.51581	12.52435	10.66818	6.966332	34.01259	5.55802
24576.34	1.630919	0.026341	0.001059	59.891	22.19662	13.3572	10.89836	31.71598	11.29826
26884.07	0.847689	0.025822	0.000958	54.86145	26.51267	16.3456	15.42167	30.08439	11.091

29116.87	0.200997	0.024917	0.000915	47.21099	26.07306	18.25197	17.95465	25.11286	8.118412
31904.45	-0.157	0.023521	0.000879	39.96513	23.0609	17.98902	17.97717	20.19014	5.083731
19839.27	5.8081	0.051402	0.001274	84.91416	0	26.11645	0	21.6289	0
20264.67	5.867483	0.047547	0.001275	83.54395	0	27.8899	0	21.09921	0
21030.76	5.555583	0.044123	0.001269	81.35767	0	23.96066	0	21.37308	0
21669.94	5.372272	0.041957	0.001284	80.57629	0.193319	21.63803	0.193319	24.33983	0
22349.24	5.063271	0.037802	0.001273	78.94516	0.867343	17.05053	0.867343	28.85909	0
23367.73	4.671354	0.034078	0.00124	76.46006	2.343325	14.42567	2.343325	32.07859	0
24432.4	4.160217	0.031009	0.0012	72.86473	4.967739	14.56643	4.893839	34.22683	0.073899
25699.83	3.615698	0.029688	0.001149	67.97052	8.713929	15.74718	8.16898	34.68153	0.544949
27677.91	2.745095	0.028597	0.001059	62.84338	14.03062	16.73187	11.1751	33.75221	2.855518
30153.84	1.67156	0.028283	0.001012	56.45497	21.9943	19.12198	15.41335	29.55171	6.58095
33827.49	1.009148	0.02845	0.000972	52.88456	27.32477	22.49177	20.92325	25.69689	6.401517
19839.22	5.808091	0.051402	0.001274	84.91413	0	26.11629	0	21.62894	0
20264.14	5.86748	0.047547	0.001275	83.54592	0	27.89042	0	21.09976	0
21062.33	5.56968	0.044497	0.001273	81.44833	0	24.11552	0	21.31592	0
22126.21	5.582822	0.043825	0.001291	81.42191	0	23.47307	0	23.68474	0
23268.13	5.638347	0.042439	0.001296	81.38495	0	21.68466	0	27.4042	0
24798.35	5.735097	0.040159	0.001282	80.89603	0	21.06472	0	30.28967	0
26471.39	5.824752	0.037694	0.001268	78.69988	0.146031	22.163	0.146031	31.94716	0
28050.73	5.872672	0.036582	0.001248	76.45218	0.836562	21.92088	0.836562	33.66615	0
30207.22	5.950092	0.034774	0.00121	74.12485	2.612119	19.85414	2.612119	32.84053	0
33171.12	6.075116	0.034085	0.001226	72.16074	6.034012	19.34467	6.034012	30.75165	0
36424.16	6.136377	0.032053	0.001239	68.52709	9.153972	18.57711	9.153972	28.10967	0
19838.2	5.807818	0.051402	0.001274	84.91335	0	26.11743	0	21.63006	0
20264.63	5.867533	0.047548	0.001275	83.54372	0	27.89135	0	21.09706	0
21183.1	5.552626	0.045373	0.00128	81.7412	0	24.76987	0	21.26279	0
22419.86	5.655726	0.045161	0.001327	81.90832	0	24.81446	0	23.23881	0
23734.19	5.872965	0.044781	0.001358	82.37675	0	24.11674	0	26.20092	0
25519.28	6.178531	0.044872	0.001384	82.44005	0	24.59447	0	28.63146	0
27547.46	6.542806	0.045349	0.001402	81.24721	0	26.95382	0	29.87575	0
29708.67	6.978726	0.045821	0.001423	79.96201	0	28.85674	0	30.53774	0
32869.23	7.88047	0.046392	0.001475	80.15825	0	30.36393	0	28.88606	0
36318.51	8.756085	0.046912	0.001565	79.16733	0	29.87672	0	26.97025	0
40110.3	9.486295	0.046741	0.001671	77.04949	0	27.53198	0	26.6225	0
19184.14	5.29564	0.053963	0.001379	85.0396	0	26.37726	0	22.02245	0
19726.91	5.726885	0.054685	0.001405	85.21006	0	27.31941	0	21.82338	0
21508.98	6.058537	0.055119	0.001428	85.20201	0	27.38981	0	21.99713	0
21806.47	5.671886	0.053819	0.001406	82.95487	0	25.53597	0	23.03391	0
18295.05	3.516482	0.037069	0.001062	73.76847	6.857961	15.44822	2.624503	22.86388	2.557044
18263.84	2.302962	0.029564	0.001042	67.56903	19.30582	14.82986	7.234551	21.23857	6.826259
18321.86	1.584402	0.028497	0.001024	62.5259	27.12858	15.69666	10.84654	19.77526	9.080469
17655.58	0.854042	0.026635	0.000984	51.90783	23.28397	12.32705	8.567382	17.02868	8.030078
17112.77	0.337406	0.02526	0.000953	42.83061	19.93126	9.784841	6.846585	14.49925	7.057151
16737.77	-0.05879	0.024183	0.000926	34.46482	16.35885	7.637264	5.356	11.89388	5.867964
16575.23	-0.30601	0.023315	0.000905	27.7071	13.17741	5.87592	4.109657	9.737147	4.815968
19184.14	5.29564	0.053963	0.001379	85.0396	0	26.37726	0	22.02245	0

19726.91	5.726885	0.054685	0.001405	85.21006	0	27.31941	0	21.82338	0
21508.98	6.058537	0.055119	0.001428	85.20201	0	27.38981	0	21.99713	0
22484.26	5.941663	0.054994	0.001441	83.86278	0	26.95446	0	22.44834	0
20380.37	4.647856	0.040322	0.001168	79.32864	1.03599	20.2833	1.03599	23.54479	0
19640.26	3.671928	0.034846	0.001148	73.91145	8.546376	18.03439	5.809357	22.88315	2.020872
19137.1	2.408691	0.031857	0.001095	66.30975	18.41341	17.09321	10.90403	20.84733	5.041243
18938.61	1.773248	0.031003	0.001082	63.04929	23.13655	16.42607	10.932	20.6529	7.581254
18766.97	1.371818	0.030175	0.001068	58.57635	24.77506	15.78538	10.80645	19.67947	8.367757
18537.32	0.939486	0.029026	0.001044	52.777	23.22236	14.49653	10.08583	18.05593	7.884467
18198.97	0.507272	0.027487	0.001009	45.24524	20.54332	12.23026	8.607551	15.77758	7.09157
19184.14	5.29564	0.053963	0.001379	85.0396	0	26.37726	0	22.02245	0
19726.91	5.726885	0.054685	0.001405	85.21006	0	27.31941	0	21.82338	0
21508.98	6.058537	0.055119	0.001428	85.20201	0	27.38981	0	21.99713	0
22544.62	5.967047	0.055144	0.001445	83.93117	0	27.11635	0	22.37521	0
21513.11	5.193186	0.044023	0.001251	81.19252	0.005021	23.5088	0.005021	23.24896	0
20910.01	4.708998	0.039479	0.001236	77.54395	0.684693	21.79544	0.684693	23.4154	0
20806.14	4.543861	0.039753	0.001245	74.45199	1.213232	21.73789	1.213232	23.59085	0
20416.7	3.915193	0.038165	0.001222	69.94522	4.753614	19.62189	4.380662	23.36761	0.276713
20288.94	3.228132	0.036911	0.001205	66.70903	11.08558	19.37957	8.934408	22.77771	1.582536
20639.9	2.77825	0.036484	0.001204	64.76013	15.89239	20.49102	12.99346	22.06522	2.114906
21024.55	2.476059	0.035933	0.001198	61.98057	17.89231	20.84782	13.64726	21.29614	3.069985
19184.14	5.29564	0.053963	0.001379	85.0396		26.37726		22.02245	
19773.65	5.750452	0.054781	0.00141	85.30583		27.44662		21.7937	
21997.14	6.300809	0.056657	0.001473	85.92308		28.78744		21.55174	
23647.66	6.459819	0.057566	0.001512	86.21695		30.66203		22.06415	
24409.68	6.468173	0.057658	0.001528	86.12363		32.41845		22.39153	
24750.82	6.427691	0.057732	0.001538	85.58797		34.56443		22.85705	
24888.5	6.427082	0.058125	0.001551	84.91492		36.61535		23.2095	
25224.58	6.457699	0.058881	0.001573	84.25636		38.83553		22.75033	
25590.42	6.496068	0.059728	0.001596	83.61074		40.89784		22.22343	
26131.92	6.604172	0.060508	0.001617	83.19504		42.79324		21.61762	
26748.31	6.752302	0.06134	0.001637	82.59891		44.66731		21.07545	
20488.2	5.187989	0.053407	0.001541	85.1679	0	28.16621	0	22.38295	0
22754.34	5.251368	0.051676	0.001452	82.94466	0.407539	29.79734	0.198568	22.76001	0.18347
22232.6	2.884498	0.041721	0.00132	69.79754	9.513335	17.8831	6.585928	24.73899	2.742137
22674.53	1.862288	0.040886	0.001333	61.62074	15.14187	13.50154	9.866574	24.49637	5.043157
22877.84	1.299005	0.03906	0.001358	54.05828	17.0859	11.57721	10.12095	22.41077	6.707612
23066.1	0.710857	0.038088	0.001413	44.43844	16.22068	9.345361	8.626708	20.21129	7.372408
22959.56	-0.013	0.036892	0.001477	33.02611	12.52284	6.149489	5.767473	16.23286	6.570567
22860.68	-1.12158	0.036011	0.00152	21.14913	7.136922	2.530756	2.305629	11.81148	4.681733
23338.34	-2.03066	0.035158	0.00153	12.57848	3.368281	0.766552	0.634568	8.034284	2.637252
24755.21	-2.96418	0.034654	0.001565	6.997691	1.10035	0.272789	0.199416	5.076864	0.864297
20488.2	5.187989	0.053407	0.001541	85.1679	0	28.16621	0	22.38295	0
22754.34	5.251369	0.051676	0.001452	82.94466	0.407649	29.79734	0.198704	22.76001	0.183446
23610	4.240581	0.044708	0.001356	76.88717	3.532853	24.29469	2.36388	25.61965	1.096463

23641.2	3.205621	0.043851	0.001354	70.00959	7.961689	17.96216	5.49414	27.06623	2.361499
23184.88	2.180035	0.04163	0.001366	62.63533	12.12873	12.77888	8.057003	26.49068	3.917206
23123.77	1.57812	0.040571	0.001405	54.85176	14.15819	10.44079	8.654377	24.55648	5.298179
23116.14	1.081753	0.039542	0.001468	45.88167	13.45991	8.345629	7.543968	20.93093	5.71524
23117.59	0.29283	0.038654	0.001543	35.53197	11.27678	6.175552	5.760333	16.86461	5.331958
23070.58	-0.7586	0.037829	0.001603	24.12237	7.090664	3.064458	2.825814	12.71098	4.107217
23504.01	-1.71775	0.03714	0.001626	15.29399	3.46024	0.963457	0.823206	9.000526	2.528946
20488.2	5.187989	0.053407	0.001541	85.1679	0	28.16621	0	22.38295	0
22754.34	5.251369	0.051676	0.001452	82.94466	0.407675	29.79734	0.198748	22.76001	0.183442
24259.43	4.77699	0.046547	0.001392	79.36408	2.274973	26.67613	1.517279	26.00758	0.712028
24712.49	4.171506	0.046076	0.001385	74.68364	4.52467	22.64058	3.104565	27.39733	1.361214
24120.61	3.174383	0.044017	0.001391	68.55802	7.637978	16.92295	5.27734	27.82907	2.276974
23538.08	2.290649	0.042401	0.001415	61.05826	10.72878	12.04592	7.10213	27.03315	3.482716
23206.24	1.659046	0.041355	0.001467	53.35097	11.94797	9.107426	7.427101	23.951	4.341878
23333.02	1.154156	0.042301	0.001545	50.79413	10.95202	7.896986	6.572927	22.98411	4.267655
23462.36	1.040526	0.043132	0.001617	48.91236	10.23237	7.030749	6.02439	22.19275	4.084067
23514.39	0.827986	0.043598	0.001696	44.62521	8.861025	5.64103	5.001387	20.70993	3.729333
20488.2	5.187989	0.053407	0.001541	85.1679	0	28.16621	0	22.38295	0
22754.34	5.251369	0.051676	0.001452	82.94466	0.407317	29.79734	0.198699	22.76001	0.183257
25404.08	5.5846	0.053226	0.001576	82.22418	1.560337	30.74861	1.12735	25.90522	0.409222
26474.05	5.589399	0.053319	0.001592	80.22289	2.407086	29.6203	1.791991	27.23309	0.593407
26715.38	5.363204	0.052035	0.001591	78.08753	2.96015	28.01134	2.202958	27.60805	0.737041
26791.82	5.077342	0.051086	0.001598	75.41992	3.55109	26.8714	2.649644	27.08142	0.87535
26508.97	4.707403	0.050108	0.00161	72.80107	3.709385	24.77426	2.809326	25.78329	0.871732
25644.42	3.885973	0.048906	0.001626	68.4229	4.01721	19.60835	2.98106	25.35427	0.997391
24792.44	3.038293	0.048156	0.001667	63.31241	4.522271	13.89121	3.218944	25.24384	1.248392
24095.89	2.213554	0.047694	0.001723	57.38148	5.28675	8.1953	3.520533	25.24672	1.693463
19683.39	4.900711	0.052686	0.001525	85.37362	0	26.97306	0	21.42961	0
20488.2	5.187991	0.053407	0.001541	85.1679	0	28.16621	0	22.38295	0
23229.39	5.459494	0.054421	0.001534	83.95617	0	30.92279	0	23.04163	0
25819.2	5.941658	0.057901	0.001595	82.66634	0	32.69433	0	25.40636	0
27089.01	6.142927	0.059898	0.001646	80.91136	0	32.53356	0	26.45156	0
27495.24	6.085855	0.059753	0.001706	79.21625	0	31.78639	0	26.65812	0
27814.61	6.073504	0.06002	0.001772	77.26639	0	31.93169	0	25.9048	0
27803.36	5.901086	0.060713	0.001859	75.5775	0	31.18239	0	24.36699	0
27314.9	5.402866	0.06016	0.001953	73.06262	0	28.24774	0	23.64848	0
27050.43	5.055819	0.060379	0.002054	71.15732	0	26.00091	0	23.18901	0
27010.61	4.819476	0.060519	0.002171	69.81351	0	24.14769	0	23.27217	0
19839.46	5.42352	0.05136	0.001509	83.38356	0	26.3022	0	21.11063	0
20255.15	5.275602	0.053768	0.001491	83.3698	0	26.93455	0	22.31947	0
22797.51	5.256886	0.051612	0.001426	84.5918	0.001258	19.10294	0.000581	27.34753	0.000694
22007.72	4.689595	0.035677	0.001218	82.93371	0.29964	8.716502	0.000987	24.10281	0.298543
20445.76	2.634773	0.02833	0.001292	57.93048	1.715441	2.418755	0.001035	15.35489	1.713824
23118.49	0.146171	0.024071	0.001485	24.84594	1.80112	0.519748	0.000756	8.106443	1.79972
24831.52	-1.49494	0.021971	0.00146	8.723626	1.676218	0.198098	0.000495	4.712165	1.676218

28342.75	-1.92149	0.021142	0.001419	4.134894	1.018658	0.142658	0.000382	2.430177	1.018194
32395.01	-2.18659	0.02028	0.001486	2.202238	0.313291	0.118896	0.000335	0.943114	0.312977
36571.21	-2.49649	0.019381	0.001498	1.543162	0.11581	0.088768	0.00031	0.535597	0.115519
41129.98	-2.88949	0.018028	0.001523	1.100733	0.012665	0.069725	0.000293	0.236813	0.012372
19839.46	5.415825	0.051275	0.001508	83.38356	0	26.3022	0	21.11063	0
20255.15	5.270526	0.053881	0.001494	83.3698	0	26.93455	0	22.31947	0
22797.51	5.238513	0.051776	0.001425	84.5918	0.001258	19.10294	0.000581	27.34753	0.000694
24397.83	5.359405	0.042126	0.001299	86.76845	0.615069	8.549618	0.001979	31.00085	0.61309
24346.48	4.524572	0.033877	0.001187	81.28988	5.801765	2.663951	0.005295	32.05703	5.796334
26417.89	2.912376	0.029674	0.001222	61.29428	10.24635	0.717245	0.005699	27.09891	10.24023
28586.33	0.871263	0.026662	0.001384	38.25093	10.24098	0.397783	0.004684	20.68107	10.23645
30730.65	-0.4716	0.024701	0.001428	23.47157	8.142369	0.323749	0.003335	15.92561	8.139162
33634.85	-1.38411	0.021822	0.001437	12.31745	4.024574	0.302951	0.001491	9.227515	4.02256
37812.71	-2.10621	0.01994	0.001497	4.858349	1.545028	0.268762	0.000375	3.553471	1.545028
42975.55	-2.5731	0.018803	0.001566	2.439965	0.739614	0.230675	0.00028	1.418054	0.739351
19839.46	5.415825	0.051275	0.001508	83.38356	0	26.3022	0	21.11063	0
20255.15	5.270526	0.053881	0.001494	83.3698	0	26.93455	0	22.31947	0
22797.51	5.237003	0.051776	0.001425	84.5918	0.001258	19.10294	0.000581	27.34753	0.000694
24887.58	5.521972	0.047187	0.001331	87.52772	0.55571	10.24529	0.121203	33.25942	0.434451
25850.58	5.179375	0.039108	0.00124	87.54476	5.734015	5.250639	1.10243	38.32481	4.631714
28133.97	4.361923	0.034094	0.001081	81.60893	17.56244	5.116814	3.55507	38.51997	14.00621
30497.69	3.31286	0.030727	0.001116	67.68823	21.47402	5.40403	4.724284	34.59173	16.75504
32369.66	1.833916	0.028189	0.00124	49.91375	18.83308	4.479959	4.023338	29.14257	14.80467
34959.38	0.335145	0.025187	0.001335	31.37597	11.93798	2.888566	2.502907	19.89341	9.439922
38451.2	-1.08993	0.022253	0.001461	16.03321	4.75	1.131919	0.712454	10.39668	4.0369
42561.24	-1.84408	0.019862	0.001465	9.99115	2.290265	0.477788	0.043628	6.479646	2.246018
19839.46	5.415825	0.051275	0.001508	83.38356	0	26.3022	0	21.11063	0
20255.15	5.270526	0.053881	0.001494	83.3698	0	26.93455	0	22.31947	0
22797.51	5.236026	0.051776	0.001425	84.5918	0.001258	19.10294	0.000581	27.34753	0.000694
25087.62	5.579103	0.047525	0.001339	87.42095	0.469068	10.89634	0.226973	32.93924	0.242095
26620.8	5.47452	0.042318	0.001271	87.83062	4.398361	7.481684	2.089904	37.65057	2.308456
29807.95	5.038393	0.036284	0.001146	83.86922	14.77297	9.493808	7.072561	37.54073	7.701499
33149.66	4.32779	0.033092	0.001109	75.41463	22.83902	12.3122	11.24878	34.33171	11.59024
35670.68	3.485563	0.03142	0.001152	65.48803	24.09761	12.90976	12.22836	32.35727	11.86924
38685.67	2.88414	0.029471	0.001186	55.79685	21.04203	11.36602	10.79685	28.59895	10.24518
41501.76	2.192097	0.026867	0.001209	46.22222	17.4188	9.410256	8.854701	23.45299	8.564103
45951.07	2.150599	0.023952	0.001197	42.86066	15.70492	8.803279	8.278689	21.83607	7.430328
19839.46	5.415825	0.051275	0.001508	83.38356	0	26.3022	0	21.11063	0
20255.15	5.270526	0.053881	0.001494	83.3698	0	26.93455	0	22.31947	0
22797.51	5.238395	0.051776	0.001425	84.5918	0.001258	19.10294	0.000581	27.34753	0.000694
26029.19	5.939408	0.051526	0.001378	88.33974	0.246323	13.95256	0.232013	32.18497	0.014284
29027.35	6.487295	0.050342	0.00135	90.43389	2.550962	13.16479	2.443913	37.28505	0.107243
33220.68	6.780857	0.046985	0.001228	90.09747	10.50682	17.53411	10.01949	38.09942	0.487524
37839.13	6.86224	0.042571	0.001178	87.69231	21.10256	24.29915	19.60684	35.58974	1.497436
40893.18	6.538844	0.038512	0.001149	82.97189	26.45783	26.21687	23.62249	34.36948	2.838554
43224.97	6.163431	0.03382	0.001138	76.44201	26.5674	24.05956	22.75862	31.7163	3.806426
45403.63	5.642486	0.030155	0.001102	68.88281	25.28125	22.17969	21.46094	28.20313	3.81875

49566.89	5.5551	0.027327	0.001067	63.33587	23.35106	21.35258	20.6079	26.13222	2.74772
19839.46	5.423465	0.05136	0.001509	83.38356	0	26.3022	0	21.11063	0
20255.15	5.275765	0.053768	0.001491	83.3698	0	26.93455	0	22.31947	0
23054.99	5.907096	0.053987	0.001588	84.81174	0	21.8411	0	24.93618	0
27232.87	7.043264	0.059243	0.0016	89.31104	0	20.74468	0	27.63425	0
32247.11	8.31389	0.067889	0.001616	92.56791	0	23.94669	0	32.14762	0
37883.23	9.842227	0.073512	0.001552	93.50427	0	30.20513	0	32.35043	0
44760.13	11.79434	0.075045	0.001575	93.49711	0	38.38873	0	30.43353	0
51765.18	13.8938	0.076389	0.001594	92.8934	0	44.66371	0	29.41624	0
58807.64	15.7926	0.075702	0.001644	91.30184	0	47.78226	0	27.54032	0
63671.5	16.65145	0.074419	0.001689	88.07799	0	48.8468	0	25.6546	0
68700.62	17.09799	0.073224	0.001725	83.88158	0	48.69518	0	24.47917	0

Primary energy (% oil)	Primary energy (% oil CCS)	Primary energy (% nuclear)	Primary energy (% solar)	Primary energy (% wind)	Primary energy (% geothermal)	Primary energy (% hydro)	Primary energy (% biomass)	Primary energy (% biomass CCS)	Primary energy (% trad biomass)
38.08227	0	2.170833	0.003586	0.081466		2.299237	9.55969	0	8.27698
33.94522	0	1.961452	0.024	0.242912		2.448657	10.42106	0	8.017288
32.05327	0.044818	2.125988	0.373569	0.949272		3.278688	8.93334	0.10504	4.434956
21.83565	0.260438	2.726493	0.811625	1.434764		4.480825	18.71338	2.742614	2.706408
10.90966	0.478369	2.006716	6.551799	4.121152		5.35785	26.49344	9.635962	2.337256
7.814271	0.340982	0.849163	11.15775	7.078476		4.579424	28.65817	10.68169	1.912884
6.181001	0.129036	0.67855	14.35862	6.806388		4.071601	31.30639	12.10618	1.423615
5.213311	0.123654	0.698525	16.10635	4.98096		4.174564	34.73574	14.73821	0.988238
4.595394	0.137059	0.8432	17.78888	5.003167		4.369516	40.16283	19.49902	0.738612
4.280803	0.129261	1.063713	18.865	6.020765		4.497867	45.15952	25.15639	0.534228
4.026545	0.088916	0.998814	18.61046	5.554478		4.450078	51.80702	33.14769	0.328312
38.08227	0	2.170833	0.003586	0.081466		2.299237	9.55969	0	8.27698
33.94522	0	1.961452	0.024	0.242912		2.448657	10.42106	0	8.017289
31.42775	1.85E-17	1.929664	0.293204	0.80466		3.012323	7.281276	0	4.241955
26.78006	0.004253	1.977614	1.016873	1.663069		3.478409	8.005654	0.034091	2.508006
22.05637	0.092436	1.537974	3.796802	2.925597		3.904536	11.79922	1.140104	2.260969
19.93039	0.103133	0.707179	8.591632	4.406111		4.061698	15.29719	3.101071	1.875653
17.39183	0.055289	0.494351	12.42319	5.122616		4.046274	20.6858	6.484656	1.427011
14.72489	0.011531	0.372206	15.57107	5.360615		3.997869	26.25636	10.59521	1.076121
9.602381	0.007814	0.36216	17.14308	5.293344		3.991607	35.33962	18.15047	0.79902
6.768699	0.003346	0.435338	17.03513	4.583927		4.274131	42.09906	24.74271	0.554606
6.549971	0.004123	0.448553	20.40479	4.736437		4.451006	40.14312	23.19541	0.351506
38.08227	0	2.170833	0.003586	0.081466		2.299237	9.55969	0	8.27698
33.94451	0	1.961411	0.024	0.242907		2.448606	10.42294	0	8.017121
31.23642	8.18E-22	1.884552	0.283642	0.778678		2.953254	7.226259	5.06E-26	4.190125
25.90727	1.67E-09	1.766298	0.739103	1.364912		3.170844	7.708915	4.60E-26	2.47751
21.31696	1.07E-07	1.216691	2.277078	2.474081		3.380478	10.05848	6.89E-05	2.222137
19.82236	3.06E-07	0.514846	5.860486	3.968358		3.399821	11.27845	0.002727	1.858127
18.09172	0.00057	0.330826	9.800124	4.424375		3.46468	13.06478	0.135451	1.457988
16.00223	0.001203	0.209757	14.45645	5.106993		3.693856	16.79531	1.174223	1.13577
11.76479	0.001317	0.139486	17.66186	5.826825		3.942314	24.68318	5.379058	0.863194
7.295873	0.002411	0.168117	18.02758	5.599717		4.14498	37.42763	15.58775	0.583309
5.674801	0.002768	0.203011	18.74792	5.067254		4.253577	42.52323	21.17006	0.341319
38.08227	0	2.170833	0.003586	0.081466		2.299237	9.55969	0	8.27698
33.94452	0	1.961412	0.024	0.242907		2.448607	10.42293	0	8.017123
31.19624	3.21E-21	1.8842	0.283084	0.777639		2.951752	7.314605	6.92E-22	4.188355
25.65717	9.49E-06	1.729944	0.688459	1.289664		3.11479	7.503848	9.49E-06	2.474407
20.68332	8.59E-06	1.121212	1.790208	2.178823		3.178537	9.704668	8.59E-06	2.198924
18.95698	5.25E-06	0.433074	4.27687	3.394615		3.077119	10.89243	5.21E-06	1.809548

17.41009	2.44E-07	0.251102	7.056314	3.857251		3.087111	11.82362	3.70E-13	1.420342
15.54181	5.57E-07	0.128566	11.45208	4.170055		3.262427	14.18387	0	1.114457
12.26718	1.78E-05	0.049374	15.60445	5.030383		3.544052	18.24237	0.16867	0.892652
9.325088	0.003201	0.068863	18.23662	5.801074		3.905409	22.71285	1.268353	0.654595
7.425195	0.002909	0.08107	19.86912	5.922335		4.275952	27.08599	3.57419	0.399924
38.08227	0	2.170833	0.003586	0.081466		2.299237	9.55969	0	8.27698
33.94452	0	1.961412	0.024	0.242907		2.448607	10.42293	0	8.017123
31.20331	0	1.883803	0.282789	0.776986		2.950988	7.32542	0	4.187171
25.54727	0	1.723789	0.676695	1.269546		3.103955	7.886172	0	2.462735
20.47837	0	1.098653	1.689189	2.107853		3.127798	9.81648	0	2.186689
18.89413	0	0.418245	3.93447	3.256509		3.019696	10.42633	0	1.801629
17.23087	0	0.232682	6.229177	3.601585		2.966081	11.23107	0	1.400886
15.14083	0	0.106117	9.495554	3.717714		3.011656	13.19767	0	1.084367
11.95755	0	0.026402	13.33495	4.202801		3.167478	16.34285	0	0.872257
9.332095	0	0.024927	15.73899	4.440737		3.396636	18.57493	0	0.640093
7.739392	0	0.018294	16.82034	4.538718		3.75146	19.60329	0	0.399827
37.1603		2.145889	0.066319	0.082468	0.077085	2.283694	10.43273	0	6.313469
34.6137		1.979246	0.495561	0.331374	0.109391	2.574799	10.78776	0	6.100142
36.25804		2.163166	1.81131	1.163108	0.1058	2.673548	10.85672	0	4.928419
33.03002		3.856933	5.200909	4.637629	0.258661	4.221062	14.39839	0.188153	5.140015
19.471		6.389369	8.64211	9.795315	0.667645	5.479725	17.65932	1.069871	4.384678
6.092513		10.81057	11.63746	12.98664	0.964196	5.636602	21.67605	3.618373	3.276749
2.278912		16.13354	13.32718	15.09036	1.224668	5.587959	25.04442	7.809569	2.161494
1.59883		18.18411	15.35451	18.10632	1.387719	5.510832	27.03789	15.33364	1.241363
1.14318		17.59508	16.82674	21.23927	1.415578	5.297676	27.99792	21.12146	0.388151
0.638776		14.76196	19.17322	23.8167	1.418308	5.038889	28.49376	21.64451	0
0.354858		9.908487	22.55887	26.56851	1.422923	4.729076	28.11109	21.31132	0
37.16881		2.145708	0.066313	0.083322	0.077078	2.283072	10.43185	0	6.312938
34.55573		1.97552	0.494828	0.331549	0.109186	2.569354	10.97604	0	6.08866
36.12345		2.199768	1.852565	1.162165	0.105921	2.676237	11.16208	0	4.934017
34.92815		3.095242	3.766538	2.860195	0.093713	3.281307	11.87584	0.145586	4.451092
30.97194		4.247915	5.831626	4.584094	0.086349	3.505541	12.22775	0.578732	3.632962
21.39871		6.568894	7.530661	6.176945	0.123933	4.032362	13.22415	1.722787	2.729923
13.28154		9.440858	8.85876	7.642731	0.171336	4.064544	14.30136	4.644696	1.818827
5.273943		12.12454	10.67283	9.386063	0.263691	4.206149	16.41603	10.32303	1.033692
1.610703		13.3728	12.44436	12.88995	0.496193	4.268242	18.83825	14.29835	0.324748
0.597582		13.44126	14.47229	17.60157	0.721082	4.260131	20.93494	16.06436	0
0.257258		12.03509	17.02242	22.61175	0.92421	4.085852	22.20367	16.97384	0
37.16881		2.145708	0.066313	0.083322	0.077078	2.283072	10.43185	0	6.312938
34.55484		1.975469	0.494815	0.33154	0.109183	2.569287	10.97855	0	6.088502
36.13187		2.197578	1.822875	1.15422	0.105815	2.659127	10.91462	0	4.929106
35.34476		2.06784	3.375006	2.106263	0.08653	2.724201	10.0523	0.046203	4.155201
33.37892		2.272131	5.110403	3.558816	0.020617	3.171846	9.798535	0.24562	3.33233
28.43113		3.229936	6.382207	5.001338	0.044558	3.166755	10.49543	0.884253	2.485626
20.83505		5.518461	7.68696	6.414187	0.074449	3.500935	11.29892	2.756701	1.697675
14.81782		9.054554	8.522221	7.242783	0.103981	3.580994	11.61534	6.550655	0.967027
8.431461		11.45038	9.250169	8.234528	0.164093	3.563697	12.49095	9.313983	0.296739

3.846166		12.58736	10.80778	11.08737	0.267421	3.680703	14.3823	10.8751	0
1.785957		12.98019	12.29359	14.60132	0.444176	3.592446	16.162	12.33581	0
37.16881		2.145708	0.066313	0.083322	0.077078	2.283072	10.43185	0	6.312938
34.55484		1.975469	0.494815	0.33154	0.109183	2.569287	10.97855	0	6.088502
36.02393		2.191051	1.803722	1.040515	0.105509	2.65144	10.85166	0	4.914855
34.59844		1.896104	3.215046	2.025035	0.083161	2.623144	9.585094	0.014119	4.060458
33.03554		1.642887	4.677738	3.093126	0.018388	2.927352	8.701292	0.07242	3.177852
29.95579		2.166489	5.739752	4.172609	0.016854	2.827028	8.623175	0.273809	2.335993
24.07147		3.232798	6.521202	5.766095	0.014659	2.806241	8.799485	0.793995	1.585685
17.54181		5.674192	7.496251	6.767976	0.009715	2.930473	9.158872	2.133165	0.924753
12.3593		9.177964	8.104397	7.265963	0.018136	3.160529	9.446062	4.51617	0.288229
7.781287		13.02224	9.270311	7.814636	0.067095	3.413565	9.9758	6.729375	0
4.695907		14.01544	9.736554	9.462634	0.128096	3.243578	10.54813	7.970213	0
37.16889		2.145713	0.066313	0.083322	0.077079	2.283077	10.43188	0	6.312952
34.55573		1.97552	0.494828	0.331549	0.109186	2.569154	10.97604	0	6.08866
36.0169		2.17893	1.801018	1.01695	0.105351	2.607959	10.84267	0	4.907489
34.26409		1.721007	3.149203	1.775254	0.078711	2.537901	9.320122	0	3.976726
32.29609		1.052775	4.335817	2.54193	0.016167	2.763788	7.910958	0	3.052353
29.54165		0.769886	4.98581	3.506022	0.014538	2.578543	7.254665	0	2.201229
24.58972		1.193515	5.670036	4.728328	0.012523	2.466531	7.234218	0	1.463545
20.86515		2.028838	6.248403	5.951957	0.00377	2.443088	6.878573	0	0.84725
21.43018		3.723261	6.798038	6.859817	0.004888	2.372432	6.124725	0.002933	0.264095
22.06441		5.244559	7.385874	7.281717	0.004615	2.293612	5.636843	0.031039	0
21.8403		7.820124	7.830678	7.127195	0.004475	2.790374	5.917293	0.118626	0
37.16586		2.145824	0.066317	0.083327	0.077083	2.282979	10.43242	0	6.313278
34.5553		1.975473	0.494816	0.331541	0.109183	2.569093	10.97857	0	6.088514
35.70854		2.057451	1.790751	0.948267	0.10475	2.6322	10.72659	0	4.879511
33.85505		1.671473	3.076314	1.538307	0.07693	2.534652	9.19805	0	3.92464
32.05909		0.966039	4.145056	2.220171	0.014252	2.528909	7.755615	0	2.992416
29.21411		0.512251	4.737523	2.922147	0.012702	2.318724	7.062539	0	2.139044
24.41764		0.607293	5.269435	3.86123	0.011497	2.184298	6.823877	0	1.406376
20.56754		0.974369	5.628203	4.833383	0.003263	2.189487	6.415905	0	0.799968
20.90827		1.561241	5.592313	5.054741	0.002965	2.134388	5.504095	0	0.242706
22.32036		2.488094	5.698301	5.640777	0.002727	2.039636	4.968998	0	0
22.895		3.475857	6.053499	6.479566	0.000767	1.911514	5.034295	0	0
36.63988	0	2.202857	0.002275	0.082024	0.046154	2.325435	10.29389	0	
36.06729	0	2.075173	0.019158	0.092209	0.044109	2.445194	10.10706	0	
35.81507	0	2.208578	0.035433	0.18587	0.042647	2.576661	9.742406	0	
34.38499	0	2.942711	0.159141	0.676525	0.043881	2.830203	10.3864	0	
35.45639	1.676398	3.707183	0.763785	1.890929	0.055191	4.196243	15.61084	0.753797	
31.50062	5.245027	2.985554	1.482161	2.661319	0.056974	4.156616	21.08115	5.171067	
27.054	7.20158	2.294864	2.075887	3.709791	0.058096	4.041289	25.28726	10.47234	
22.5521	6.686528	2.21028	2.957838	5.58765	0.061815	4.362538	32.90513	16.29116	
18.54652	6.027525	2.218388	4.285147	7.668911	0.065119	4.436231	38.48879	20.3909	
14.93367	5.134887	2.167541	5.77291	10.15704	0.067892	4.348389	43.01482	23.6881	
12.09403	4.251798	2.036974	7.411216	12.5058	0.070154	4.221999	46.04045	25.80002	
36.63988	0	2.202857	0.002275	0.082024	0.046154	2.325435	10.29389	0	

36.06729	0	2.075173	0.019158	0.092209	0.044109	2.445194	10.10706	0
35.81507	0	2.208578	0.035433	0.18587	0.042647	2.576661	9.742406	0
34.45997	0	2.854003	0.11698	0.470867	0.041862	2.743553	9.904164	0
35.50052	0	3.257766	0.389313	1.007133	0.047777	3.503497	12.46002	0
32.99391	0.716147	2.949585	0.836399	1.558342	0.051178	3.758798	16.9284	0.494917
28.36923	2.468151	2.60561	1.381542	2.471418	0.053836	3.885025	23.28702	5.314268
25.97032	4.623291	2.208264	1.762917	3.215005	0.055886	3.909979	25.79297	11.00117
23.11149	5.600855	1.973458	2.217705	4.189178	0.057725	3.891735	29.08841	13.38544
20.22454	5.252059	1.846906	2.946433	5.573741	0.059708	3.87243	32.91855	16.22344
17.23739	4.844199	1.865052	4.051757	7.429284	0.062359	3.845304	37.49596	19.55806
36.63988	0	2.202857	0.002275	0.082024	0.046154	2.325435	10.29389	0
36.06729	0	2.075173	0.019158	0.092209	0.044109	2.445194	10.10706	0
35.81507	0	2.208578	0.035433	0.18587	0.042647	2.576661	9.742406	0
34.43961	0	2.846362	0.114453	0.458651	0.041561	2.73612	9.865969	0
34.43476	0	2.922874	0.310944	0.818487	0.044439	3.119416	11.58598	0
32.33311	0	2.400829	0.603162	1.140964	0.046856	3.332102	14.92711	0
29.12325	0	1.821092	0.818669	1.481716	0.048293	3.244641	18.12869	0
26.95573	0.09624	1.591599	1.06681	1.931326	0.050629	3.371909	22.03767	0
24.55175	0.56862	1.428165	1.388939	2.524026	0.05223	3.389031	24.50393	0.607893
22.20388	0.78403	1.203517	1.658929	3.066811	0.05255	3.266407	25.98735	2.588474
19.83661	1.175056	1.043042	1.939088	3.690821	0.052984	3.109663	28.17982	5.038051

36.63988		2.202857	0.002275	0.082024	0.046154	2.325435	10.29389	
36.06551		2.033206	0.01899	0.092236	0.044004	2.415237	10.08347	
35.58391		1.994734	0.025099	0.09759	0.042209	2.400055	9.511012	
33.49077		1.92685	0.036077	0.108024	0.041237	2.290449	9.374646	
31.31365		1.694665	0.052208	0.122659	0.041747	2.370223	9.589364	
28.16649		1.373972	0.072508	0.134072	0.042459	2.643684	10.14005	
25.09007		1.106088	0.090148	0.168717	0.043295	2.764819	10.90694	
22.6705		0.907373	0.108949	0.206389	0.043891	2.698555	11.77363	
20.48947		0.755262	0.137506	0.26166	0.044302	2.633182	12.55278	
18.78419		0.629862	0.166881	0.318606	0.04437	2.52305	13.11796	
16.85614		0.541752	0.201121	0.386006	0.044493	2.383732	13.84008	

34.61874	0	1.950883	0.023692	0.241865	0.048194	2.436173	10.13129	0	6.009969
30.38731	0.025501	2.320997	0.281131	0.918903	0.270713	2.084119	11.17948	0.147866	5.471741
27.17544	0.18527	6.569746	0.878438	2.804766	0.635963	2.067305	17.24625	3.277994	6.029965
23.62283	0.232138	9.57163	1.775909	3.991367	0.719687	2.041785	20.27889	7.010207	5.909532
20.07029	0.257335	11.8831	3.019368	4.719397	0.748274	2.10461	23.46697	11.52662	5.851595
14.88179	0.221568	14.23383	4.547075	4.667742	0.749597	2.195827	29.16749	17.53336	5.827096
10.64376	0.184798	16.63157	6.242994	5.071084	0.753959	2.342614	35.93168	23.7552	5.854966
6.806895	0.149559	18.8747	8.050088	5.787689	0.749801	2.512982	42.87562	29.84122	5.844396
3.777648	0.096461	18.35949	10.40007	6.815487	0.734905	2.637415	48.47415	34.91536	5.523339
1.648038	0.036638	16.77153	11.99024	6.980887	0.550277	2.590816	54.11856	40.4596	4.705944

34.61874	0	1.950883	0.023692	0.241865	0.048194	2.436173	10.13129	0	6.009969
30.38731	0.025499	2.320997	0.281131	0.918903	0.270713	2.084119	11.17948	0.147889	5.471741
26.97283	0.07251	4.079025	0.656094	1.863145	0.501712	1.946699	14.06616	1.17692	5.477832

24.98121	0.10605	7.024248	1.414469	3.036501	0.618815	1.958299	15.93808	2.660985	5.427414
23.36577	0.154521	10.04477	2.590801	4.002103	0.687015	2.076739	17.96324	4.898381	5.499399
19.8545	0.205632	12.24219	4.086304	4.469985	0.71339	2.190398	21.44597	9.122779	5.50972
16.60512	0.200703	14.48924	5.745031	4.64677	0.713216	2.326956	26.19711	14.80196	5.492453
12.49181	0.184488	16.35135	7.268441	4.95625	0.694845	2.485056	32.71209	21.13357	5.467128
8.34693	0.157633	17.58962	9.311138	5.849771	0.681376	2.668024	39.7777	27.5332	5.345361
5.330007	0.108088	17.30784	11.7853	6.7466	0.64041	2.728735	45.49713	32.82111	5.002882
34.61874	0	1.950883	0.023692	0.241865	0.048194	2.436173	10.13129	0	6.009969
30.38731	0.025485	2.320997	0.281131	0.918903	0.270713	2.084119	11.17948	0.147894	5.471741
26.68038	0.045666	3.358351	0.57842	1.57171	0.44879	1.894585	12.78406	0.761421	5.22041
24.64572	0.058891	5.212477	1.168834	2.370631	0.534336	1.873406	14.15668	1.512256	5.063052
23.806	0.083664	7.871025	2.16628	3.211891	0.606057	1.996174	15.59056	2.594585	5.134421
21.97919	0.14393	10.52698	3.64173	4.048991	0.668331	2.151843	17.90387	4.81775	5.236871
20.29254	0.17899	12.90515	5.349308	4.511534	0.6926	2.317991	20.87245	8.520211	5.283553
19.91303	0.111438	13.82544	6.339686	4.222206	0.629738	2.450453	21.73835	9.870314	5.049272
19.68886	0.123915	14.38524	7.30805	4.150461	0.577281	2.623473	22.04313	10.73277	4.627802
18.27425	0.130304	14.61555	8.966803	4.646426	0.551227	2.72753	23.86725	13.12357	4.300479
34.61874	0	1.950883	0.023692	0.241865	0.048194	2.436173	10.13129	0	6.009969
30.38731	0.025361	2.320997	0.281131	0.918903	0.270713	2.084119	11.17948	0.147819	5.471741
25.57036	0.023765	2.733752	0.479883	1.304937	0.386456	1.809219	11.06157	0.435791	4.795671
23.3695	0.021688	3.541714	0.875718	1.707244	0.426883	1.748751	11.4768	0.660796	4.493194
22.46814	0.020151	4.389102	1.436745	1.855379	0.43295	1.802293	11.996	0.828227	4.330863
21.46709	0.026097	5.202047	2.194025	2.081729	0.438474	1.890512	12.7733	1.093051	4.179877
22.24352	0.028328	6.198394	3.073309	2.272574	0.449668	2.029194	13.17579	1.306286	4.080032
23.46027	0.038759	7.763816	4.289524	2.917497	0.495541	2.240195	13.87053	1.632046	4.043143
24.17736	0.054934	9.485336	5.907123	3.719986	0.52516	2.482727	14.56726	2.183162	3.936791
23.93946	0.072754	11.09397	8.156247	4.583334	0.532766	2.661708	15.59049	3.303304	3.813734
36.97095	0	2.161235	0.003546	0.081187	0.045444	2.290318	10.04465	0	6.19849
34.61874	0	1.950883	0.023692	0.241865	0.048194	2.436173	10.13129	0	6.009969
29.99176	0	2.144503	0.257116	0.81439	0.25588	2.041498	10.53044	0	5.308898
24.56564	0	2.582107	0.457054	1.223404	0.369127	1.780131	10.92184	0	4.680989
21.92623	0	3.270516	0.81848	1.57693	0.40293	1.709052	11.31073	0	4.343355
20.77174	0	3.95582	1.314716	1.70424	0.402761	1.751174	11.65504	0	4.11144
19.4299	0	4.558848	1.960992	1.81855	0.398637	1.820995	12.17559	0	3.903855
20.02812	0	5.240238	2.658915	1.882987	0.392845	1.934725	12.31279	0	3.731981
21.1664	0	6.190975	3.490713	2.251721	0.411113	2.103192	12.48966	0	3.549225
21.9674	0	6.793447	4.336342	2.587897	0.410944	2.275486	12.43857	0	3.322954
22.39366	0	7.032665	5.246242	2.876715	0.395502	2.374482	12.26088	0	3.089674
35.98795		2.178218	0.001334	0.082867	0.047202	2.300904	12.01679	0	7.117951
34.11577		2.027054	0.047066	0.346529	0.065208	2.25184	11.90173	0	6.72966
38.14134		1.961923	0.266376	0.771539	0.065537	1.736044	10.61633	0.000549	3.736689
50.11754		3.284752	0.52578	1.67842	0.206551	2.079611	9.288513	1.551951	1.643943
40.16168		6.637025	2.942603	4.239289	0.843169	4.443007	22.95877	18.51253	0.471302
16.21849		8.110644	9.114846	6.759104	2.219888	5.521008	43.43137	41.45658	0
3.813493		8.735348	17.13988	8.990623	3.668924	5.631675	47.10862	46.14483	0

1.562174	8.342798	22.62139	9.939738	4.4814	5.174412	45.31232	43.60876	0
1.140855	7.409809	26.82213	10.58245	4.585381	4.793475	43.60556	41.12726	0
0.919108	6.515034	30.64985	11.33851	4.364694	4.548982	41.05723	38.5936	0
0.794231	5.740842	33.91026	11.32784	4.211538	4.361722	39.32234	36.95055	0
35.98795	2.178218	0.001334	0.082867	0.047202	2.300904	12.01679	0	7.117951
34.11577	2.027054	0.047066	0.346529	0.065208	2.25184	11.90173	0	6.72966
38.14134	1.961923	0.266376	0.771539	0.065537	1.736044	10.61633	0.000549	3.736689
47.21515	2.430025	0.262228	1.148996	0.117656	1.612949	7.66186	0.392282	1.482895
46.55804	3.970129	0.688527	2.215886	0.227699	2.441276	9.171758	4.837746	0.395791
33.47224	5.85611	2.809168	3.881603	0.604976	3.70266	21.86542	19.56122	0
17.17389	7.138817	7.677339	5.638647	1.559	4.381717	35.35468	34.17807	0
7.219966	7.791791	14.45062	7.394186	2.87516	4.609876	39.40787	38.71313	0
2.783765	7.669453	21.69403	8.970692	3.993353	4.472757	40.89032	39.95367	0
1.036585	6.622889	27.41088	10.37523	4.689493	4.226079	41.81051	38.48968	0
0.791762	5.528484	30.90272	10.50833	4.80894	3.995618	41.80543	36.56442	0
35.98795	2.178218	0.001334	0.082867	0.047202	2.300904	12.01679	0	7.117951
34.11577	2.027054	0.047066	0.346529	0.065208	2.25184	11.90173	0	6.72966
38.14134	1.961923	0.266376	0.771539	0.065537	1.736044	10.61633	0.000549	3.736689
44.02716	2.152162	0.222145	0.993348	0.106652	1.49806	7.490299	0.126441	1.453714
43.96419	2.845269	0.277494	1.519182	0.152685	1.85422	5.808184	1.323529	0.372762
37.96755	3.936011	1.012084	2.633214	0.311658	2.706871	7.79146	5.185867	0
27.68823	5.136797	3.814422	4.00106	0.801591	3.535525	15.02651	13.5631	0
16.2963	6.307458	9.14967	5.595129	1.749366	4.016235	23.26738	22.43531	0
8.593992	7.060078	16.37597	7.420543	2.843023	4.188953	30.75581	30.23256	0
4.499077	6.829336	23.15498	9.243542	4.04059	4.091328	36.61439	36.19004	0
3.032743	5.906195	28.20354	9.884956	4.90885	3.967257	37.17699	36.80531	0
35.98795	2.178218	0.001334	0.082867	0.047202	2.300904	12.01679	0	7.117951
34.11577	2.027054	0.047066	0.346529	0.065208	2.25184	11.90173	0	6.72966
38.14134	1.961923	0.266376	0.771539	0.065537	1.736044	10.61633	0.000549	3.736689
43.57987	2.103382	0.215975	0.981166	0.103932	1.470993	7.711026	0.108716	1.442123
42.69216	2.658637	0.191481	1.394511	0.13051	1.712405	6.083447	1.073637	0.361977
36.83467	3.58136	0.478927	2.193135	0.175755	2.338692	7.366935	4.004997	0
28.76098	4.626341	2.053659	3.129756	0.344878	3.002927	11.43415	9.149268	0
20.21179	5.437385	5.38674	4.289134	0.715378	3.349908	15.29466	13.7477	0
15.82312	5.864273	10.24518	5.630473	1.238179	3.553415	17.662	16.61121	0
13.35897	5.82906	15.39316	7.187179	1.964957	3.673504	19.76923	19.04274	0
12.22131	5.152459	18.7541	7.741803	2.391803	3.59918	19.4918	18.98361	0
35.98795	2.178218	0.001334	0.082867	0.047202	2.300904	12.01679	0	7.117951
34.11577	2.027054	0.047066	0.346529	0.065208	2.25184	11.90173	0	6.72966
38.14134	1.961923	0.266376	0.771539	0.065537	1.736044	10.61633	0.000549	3.736689
42.2022	1.824566	0.206837	0.857957	0.092275	1.356831	7.324765	0.018153	1.389956
39.97267	1.817561	0.133698	0.935429	0.105056	1.291425	5.281859	0.145883	0.331967
34.47368	2.165692	0.103411	1.28655	0.104971	1.573099	4.703704	0.495127	0
27.80342	3.011111	0.598205	1.8	0.099487	2.102564	4.68547	1.016239	0
22.38554	4.412851	2.211245	2.804819	0.108755	2.53494	4.970281	1.694779	0
20.66614	5.876959	5.131661	4.163009	0.169906	2.846395	5.36442	2.581505	0
18.5	6.423437	9.335938	5.714844	0.357969	3.171094	6.128906	3.807813	0

15.84347	5.775076	13.48784	6.357143	0.572948	3.332827	7.105623	4.958967	0
35.98795	2.178218	0.001334	0.082867	0.047202	2.300904	12.01679	0	7.117951
34.11577	2.027054	0.047066	0.346529	0.065208	2.25184	11.90173	0	6.72966
38.03446	1.935227	0.263401	0.720166	0.057642	1.686343	10.5217	0	3.694959
40.93212	1.557751	0.197695	0.660208	0.063576	1.204407	7.006079	0	1.328521
36.4736	1.100974	0.115633	0.516146	0.067289	0.908457	4.722706	0	0.298821
30.96581	0.751624	0.013385	0.728462	0.075838	0.847778	4.079487	0	0
24.70376	0.449061	0.026908	1.090318	0.073627	1.011561	3.833092	0	0
18.83883	0.325888	0.180711	1.490482	0.078617	1.319162	3.68401	0	0
16.0023	0.55674	0.765553	1.967166	0.115265	1.628456	3.631912	0	0
13.59331	1.072423	2.233426	2.722563	0.230251	1.82507	3.837883	0	0
10.73465	1.804276	4.434759	3.411732	0.37648	1.973136	4.10636	0	0

Electricity use	Electricity per capita	Final heat energy	Final heat per capita	Final transport energy	Final transport per capita	Final industry energy	Final industry per capita	Economic consumpti on per capita	Secondary electricity
1.49E+13	2275.245	3.68E+12	563.5787	2.51E+13	3840.317	2.88E+13	4410.545	5287.719	18163.79
1.76E+13	2542.709	4.08E+12	589.978	2.48E+13	3587.43	3.38E+13	4884.978	5842.846	21268.47
2.05E+13	2702.585	3.24E+12	428.0241	2.6E+13	3433.458	3.28E+13	4328.749	8017.064	24145.1
1.95E+13	2424.081	2.03E+12	251.9005	1.73E+13	2147.409	2.99E+13	3710.446	11685.99	22576.69
2.31E+13	2758.613	1.57E+12	186.9968	1.83E+13	2180.069	3.12E+13	3724.41	16318.04	27477.11
3.06E+13	3591.944	1.4E+12	164.3437	1.98E+13	2324.468	3.37E+13	3953.894	21221.87	35266.97
3.8E+13	4468.973	1.14E+12	134.4765	2.03E+13	2392.594	3.55E+13	4175.651	26007.33	42485.01
4.35E+13	5242.284	8.69E+11	104.7354	2.14E+13	2576.279	3.51E+13	4229.454	31302.46	48749.79
4.65E+13	5839.054	6.59E+11	82.74335	2.28E+13	2858.682	3.35E+13	4200.638	37003.46	52279.49
4.71E+13	6273.675	4.82E+11	64.15988	2.43E+13	3229.437	3.08E+13	4100.994	43418.78	52559.99
4.56E+13	6558.366	3.48E+11	49.98455	2.54E+13	3652.131	2.78E+13	3997.614	50603.03	50344.04
1.49E+13	2275.245	3.68E+12	563.5787	2.51E+13	3840.317	2.88E+13	4410.545	5287.719	18163.79
1.76E+13	2542.709	4.08E+12	589.978	2.48E+13	3587.43	3.38E+13	4884.974	5842.846	21268.47
2.28E+13	3006.366	3.73E+12	492.6238	2.84E+13	3753.5	3.72E+13	4916.569	8017.064	26803.27
2.83E+13	3513.729	3.08E+12	382.0438	2.94E+13	3649.56	3.9E+13	4841.423	11685.99	33175.08
3.33E+13	3970.169	2.46E+12	293.6918	3.11E+13	3704.128	4.06E+13	4838.689	16318.04	38627.53
3.8E+13	4454.383	2.02E+12	236.4341	3.13E+13	3667.806	4.07E+13	4766.407	21221.87	43758.2
4.36E+13	5133.779	1.53E+12	180.1213	3.15E+13	3711.144	4.09E+13	4813.555	26007.33	49763.93
4.74E+13	5713.22	1.11E+12	134.031	3.1E+13	3730.89	3.86E+13	4650.405	31302.46	53398.96
4.95E+13	6211.946	7.88E+11	98.95449	3.04E+13	3821.031	3.53E+13	4435.432	37003.46	55745.88
4.96E+13	6610.199	5.74E+11	76.36979	3.09E+13	4114.239	3.17E+13	4224.393	43418.78	55362.63
5.33E+13	7664.569	4.19E+11	60.2261	3.07E+13	4408.924	2.91E+13	4183.053	50603.03	59249.07
1.49E+13	2275.245	3.68E+12	563.5787	2.51E+13	3840.317	2.88E+13	4410.545	5287.719	18163.79
1.76E+13	2542.709	4.08E+12	589.978	2.48E+13	3587.43	3.38E+13	4884.974	5842.846	21268.47
2.34E+13	3085.661	3.84E+12	506.9195	2.91E+13	3839.769	3.84E+13	5071.446	8017.064	27498.44
3.07E+13	3805.188	3.37E+12	418.4016	3.13E+13	3885.631	4.26E+13	5286.227	11685.99	35879.45
3.8E+13	4526.237	2.94E+12	350.1923	3.46E+13	4126.009	4.6E+13	5477.693	16318.04	43927.7
4.43E+13	5197.254	2.49E+12	292.4293	3.65E+13	4273.542	4.74E+13	5560.356	21221.87	51041.9
5.01E+13	5903.089	1.89E+12	222.1517	3.73E+13	4390.643	4.75E+13	5596.898	26007.33	57393.1
5.35E+13	6444.505	1.33E+12	160.0521	3.61E+13	4355.551	4.46E+13	5379.443	31302.46	60872.83
5.46E+13	6852.674	9.04E+11	113.5021	3.35E+13	4206.603	3.94E+13	4940.917	37003.46	61989.02
5.4E+13	7186.385	6.22E+11	82.80283	3.23E+13	4302.458	3.45E+13	4594.699	43418.78	60777.88
5.46E+13	7840.882	4.51E+11	64.78418	3.24E+13	4656.534	3.08E+13	4430.798	50603.03	60738.94
1.49E+13	2275.245	3.68E+12	563.5787	2.51E+13	3840.317	2.88E+13	4410.545	5287.719	18163.79
1.76E+13	2542.709	4.08E+12	589.978	2.48E+13	3587.43	3.38E+13	4884.974	5842.846	21268.47
2.34E+13	3089.787	3.84E+12	506.9613	2.91E+13	3841.265	3.84E+13	5072.315	8017.064	27538.55
3.11E+13	3860.165	3.42E+12	424.6863	3.17E+13	3932.749	4.32E+13	5357.077	11685.99	36398.78
3.98E+13	4741.397	3.1E+12	368.9959	3.59E+13	4283.081	4.81E+13	5731.822	16318.04	46033.26
4.76E+13	5581.516	2.69E+12	315.8886	3.86E+13	4529.668	5.13E+13	6015.547	21221.87	54940.16

5.46E+13	6431.782	2.06E+12	242.0003	4E+13	4705.862	5.14E+13	6051.66	26007.33	62495.74
5.92E+13	7129.271	1.48E+12	178.533	3.94E+13	4752.144	4.88E+13	5879.507	31302.46	67610.61
6.17E+13	7744.982	1.04E+12	130.4139	3.7E+13	4646.648	4.44E+13	5571.749	37003.46	70082.42
6.22E+13	8277.609	7.06E+11	93.9594	3.41E+13	4538.777	3.94E+13	5242.564	43418.78	70040.47
6.18E+13	8881.84	4.72E+11	67.87052	3.23E+13	4646.094	3.47E+13	4985.389	50603.03	69104.53
1.49E+13	2275.245	3.68E+12	563.5787	2.51E+13	3840.317	2.88E+13	4410.545	5287.719	18163.79
1.76E+13	2542.709	4.08E+12	589.978	2.48E+13	3587.43	3.38E+13	4884.974	5842.846	21268.47
2.34E+13	3091.159	3.84E+12	507.0614	2.91E+13	3843.439	3.84E+13	5073.877	8017.064	27549.72
3.12E+13	3869.093	3.44E+12	426.11	3.18E+13	3940.25	4.36E+13	5402.124	11685.99	36481.47
4.03E+13	4800.374	3.14E+12	374.6927	3.63E+13	4327.29	4.89E+13	5824.675	16318.04	46618.4
4.83E+13	5659.618	2.73E+12	320.547	3.91E+13	4580.144	5.15E+13	6032.597	21221.87	55696.18
5.61E+13	6610.731	2.11E+12	248.8045	4.09E+13	4814.413	5.28E+13	6211.896	26007.33	64131.75
6.25E+13	7534.523	1.57E+12	188.7637	4.13E+13	4971.172	5.17E+13	6224.025	31302.46	71430.45
6.74E+13	8456.205	1.13E+12	141.6117	3.97E+13	4980.976	4.85E+13	6091.048	37003.46	76512.61
6.96E+13	9268.71	7.87E+11	104.7328	3.75E+13	4990.918	4.42E+13	5879.032	43418.78	78414.84
6.94E+13	9974.781	5.27E+11	75.69043	3.56E+13	5117.543	3.9E+13	5602.098	50603.03	77598.23
1.51E+13	2314.913	3.04E+12	468.0656	2.41E+13	3700.999	3.25E+13	4992.728	4499.383	18078.07
1.77E+13	2578.007	3.21E+12	466.901	2.65E+13	3863.674	3.75E+13	5461.08	5239.969	20961.41
2.28E+13	2990.459	3.72E+12	488.8601	3.35E+13	4403.682	4.6E+13	6045.624	6732.211	26345.85
2.71E+13	3283.043	5.95E+12	719.7962	3.32E+13	4016.657	4.3E+13	5199.148	10016.56	31634.19
3.7E+13	4205.875	7.11E+12	809.4556	3.14E+13	3569.779	4.27E+13	4855.912	13034.33	44601.15
4.92E+13	5369.512	6.93E+12	755.5871	3.1E+13	3381.435	4.53E+13	4939.021	16318.79	62440.33
5.95E+13	6342.539	5.71E+12	608.4672	3.45E+13	3677.738	4.77E+13	5080.732	20259.99	83013.12
6.89E+13	7288.762	5.38E+12	568.4578	3.73E+13	3943.781	4.91E+13	5192.608	25365.17	101214.2
7.75E+13	8241.514	5.94E+12	631.0734	3.97E+13	4219.469	5.09E+13	5408.475	31574.82	114130.1
8.58E+13	9267.942	6.58E+12	710.8682	4.17E+13	4511.561	5.23E+13	5650.114	39556.37	125335.4
9.49E+13	10509.71	7.14E+12	790.6095	4.45E+13	4925.44	5.4E+13	5980.96	47741.57	138391.5
1.51E+13	2314.913	3.04E+12	468.0656	2.41E+13	3700.999	3.25E+13	4990.977	4499.383	18078.35
1.77E+13	2578.007	3.21E+12	466.901	2.65E+13	3863.674	3.75E+13	5462.01	5237.582	20965.29
2.28E+13	2997.575	3.93E+12	515.8304	3.34E+13	4389.412	4.61E+13	6059.347	6717.19	26410.3
2.82E+13	3416.855	5.75E+12	695.6226	3.76E+13	4546.326	4.88E+13	5911.918	10011.87	32428.64
3.48E+13	3957.848	6.85E+12	779.0765	3.94E+13	4481.373	5.2E+13	5919.717	13161.32	40040.59
4.45E+13	4852.953	8.2E+12	894.5199	3.79E+13	4137.082	5.57E+13	6076.022	16615.48	51553.1
5.57E+13	5939.075	9.4E+12	1001.927	4.06E+13	4331.107	5.8E+13	6181.254	20675.73	64916.16
6.83E+13	7226.138	8.69E+12	919.1434	4.47E+13	4729.012	5.92E+13	6259.352	25870.86	80639.79
7.95E+13	8450.484	8.9E+12	946.492	4.87E+13	5174.613	6.15E+13	6537.716	32203.8	96587.3
9.06E+13	9785.499	8.45E+12	912.644	5.23E+13	5653.896	6.27E+13	6780.323	40374.09	117412.6
1.03E+14	11363.55	8.64E+12	956.6781	5.67E+13	6272.503	6.42E+13	7106.29	49038.66	140093.2
1.51E+13	2314.913	3.04E+12	468.0656	2.41E+13	3700.999	3.25E+13	4990.977	4499.383	18078.35
1.77E+13	2578.007	3.21E+12	466.901	2.65E+13	3863.674	3.75E+13	5462.01	5236.345	20965.29
2.28E+13	2992.028	3.81E+12	500.5752	3.35E+13	4400.544	4.61E+13	6050.989	6715.635	26360.58
2.81E+13	3402.869	5.19E+12	627.775	4.02E+13	4865.828	5.13E+13	6204.052	10017.88	32166.97
3.41E+13	3876.289	5.78E+12	658.0344	4.52E+13	5146.963	5.59E+13	6366.963	13194.91	38730.86
4.19E+13	4567.453	6.04E+12	659.2491	4.68E+13	5101.22	6.08E+13	6625.997	16696.74	47542.26
5.24E+13	5579.002	6.44E+12	686.7271	4.43E+13	4716.28	6.5E+13	6925.551	20791.65	59637.27
6.14E+13	6487.874	8.38E+12	886.1868	4.8E+13	5077.612	6.75E+13	7139.84	26058.75	70466.45
7.28E+13	7740.836	1.14E+13	1215.374	5.29E+13	5624.266	6.84E+13	7275.002	32473.36	84391.46

8.69E+13	9386.36	1.22E+13	1321.599	5.77E+13	6233.709	6.92E+13	7473.421	40706.42	102350.1
1.01E+14	11159.75	1.23E+13	1359.118	6.32E+13	6993.671	7.15E+13	7915.352	49573.88	120892.9
1.51E+13	2314.913	3.04E+12	468.0656	2.41E+13	3700.999	3.25E+13	4990.977	4499.383	18078.35
1.77E+13	2578.007	3.21E+12	466.901	2.65E+13	3863.674	3.75E+13	5462.01	5235.96	20965.57
2.27E+13	2986.846	3.74E+12	490.9768	3.35E+13	4403.719	4.61E+13	6061.318	6715.307	26315.3
2.82E+13	3418.435	5.08E+12	614.3938	4.08E+13	4943.493	5.28E+13	6385.002	10016.52	32292.8
3.4E+13	3872.97	4.9E+12	557.0974	4.72E+13	5373.399	5.87E+13	6674.579	13204.24	38661.42
4.16E+13	4541.036	4.88E+12	532.404	5.06E+13	5523.805	6.4E+13	6979.267	16722.38	46994.76
5.18E+13	5522.587	5.58E+12	594.6445	4.91E+13	5236.66	6.92E+13	7368.944	20846.24	58641.16
6.14E+13	6493.396	7.41E+12	784.0271	4.98E+13	5264.954	7.36E+13	7778.353	26145.28	69847.83
6.97E+13	7404.246	9.26E+12	984.3174	5.51E+13	5856.947	7.57E+13	8050.467	32605.02	80204.79
7.94E+13	8582.348	1.13E+13	1216.749	6.05E+13	6534.902	7.72E+13	8344.491	40889.07	92983.13
9.27E+13	10267.01	1.35E+13	1489.112	6.66E+13	7375.229	7.84E+13	8680.036	49832.77	109399.8
1.51E+13	2314.913	3.04E+12	468.0656	2.41E+13	3700.999	3.25E+13	4990.977	4499.383	18078.35
1.77E+13	2578.007	3.21E+12	466.901	2.65E+13	3863.674	3.75E+13	5462.01	5235.758	20965.29
2.27E+13	2986.846	3.7E+12	485.8309	3.35E+13	4403.719	4.62E+13	6066.646	6714.818	26315.3
2.84E+13	3443.113	4.49E+12	543.4867	4.12E+13	4986.192	5.39E+13	6521.067	10012.49	32525.3
3.44E+13	3910.62	3.95E+12	449.269	4.81E+13	5469.816	6.03E+13	6860.647	13205.54	38996.42
4.18E+13	4559.334	3.59E+12	391.9262	5.24E+13	5716.451	6.62E+13	7217.385	16732.53	47239.2
5.23E+13	5576.812	3.75E+12	399.2317	5.2E+13	5545.171	7.27E+13	7750.18	20864.82	58873.94
6.34E+13	6701.094	5.42E+12	572.6582	5.21E+13	5511.63	7.79E+13	8233.783	26178.99	71102.83
7.19E+13	7645.136	7.64E+12	812.4937	5.76E+13	6119.363	8.28E+13	8806.858	32680.97	81494.51
7.99E+13	8633.227	1.09E+13	1175.025	6.39E+13	6903.484	8.8E+13	9504.988	41039.12	92134.52
8.91E+13	9868.995	1.21E+13	1337.221	7.08E+13	7835.854	9.25E+13	10241.27	50056.19	103911.2
1.51E+13	2314.913	3.04E+12	468.0656	2.41E+13	3700.999	3.25E+13	4990.806	4499.383	18077.79
1.77E+13	2578.007	3.21E+12	466.901	2.65E+13	3863.674	3.75E+13	5462.01	5234.862	20965.29
2.27E+13	2988.306	3.48E+12	457.6562	3.35E+13	4403.865	4.63E+13	6083.762	6713.662	26327.8
2.86E+13	3464.362	3.95E+12	477.6564	4.14E+13	5008.415	5.45E+13	6602.329	10011.61	32725.03
3.44E+13	3912.927	3.41E+12	388.2264	4.85E+13	5516.475	6.11E+13	6952.985	13207.64	39025.31
4.18E+13	4563.515	3.18E+12	346.5746	5.31E+13	5792.37	6.74E+13	7348.926	16733.81	47290.87
5.24E+13	5580.246	3.26E+12	347.1374	5.32E+13	5672.891	7.44E+13	7922.772	20868.41	58898.94
6.41E+13	6779.696	3.84E+12	405.8777	5.3E+13	5601.511	8.07E+13	8537.824	26179.49	71849.22
7.29E+13	7748.513	5.38E+12	571.9582	5.87E+13	6235.88	8.67E+13	9214.197	32691.37	82394.79
8.11E+13	8762.902	8.68E+12	937.8885	6.58E+13	7105.38	9.24E+13	9980.011	41056.78	93178.69
9.13E+13	10104.07	1.03E+13	1136.678	7.3E+13	8078.652	9.77E+13	10820.44	50104.49	105397.6
1.52E+13	2338.436	3.07E+12	473.2591	2.31E+13	3554.893	3.53E+13	5435.19	5208.629	18070.43
1.71E+13	2481.029	3.5E+12	509.0505	2.55E+13	3699.594	3.73E+13	5416.631	5468.496	20272.07
2.12E+13	2749.881	4.38E+12	568.5572	3.21E+13	4171.628	4.48E+13	5822.349	6641.204	25103.02
2.5E+13	2939.688	5.29E+12	621.5556	3.62E+13	4249.72	5.2E+13	6110.651	7462.289	29705
2.72E+13	2940.626	5.79E+12	625.1852	3.08E+13	3332.432	4.77E+13	5150.239	7663.83	33032.28
3.2E+13	3214.756	6.52E+12	654.8523	3.16E+13	3176.86	5.01E+13	5031.925	7680.927	39278.95
3.76E+13	3556.682	7.08E+12	669.4499	3.19E+13	3016.93	5.28E+13	4988.734	7654.867	45866.73
4.49E+13	4040.69	7.74E+12	696.3479	3.09E+13	2782.058	5.43E+13	4884.222	7657.209	54747.6
5.24E+13	4502.861	8.33E+12	715.7954	3.06E+13	2629.387	5.64E+13	4845.512	7632.232	63517.3
6.05E+13	4985.775	8.86E+12	730.2682	3.11E+13	2566.328	5.92E+13	4882.278	7607.777	72840.42
6.89E+13	5457.062	9.4E+12	745.17	3.26E+13	2583.649	6.32E+13	5011.13	7654.994	82404.57
1.52E+13	2338.436	3.07E+12	473.2591	2.31E+13	3554.893	3.53E+13	5435.19	5208.629	18070.43

1.71E+13	2481.029	3.5E+12	509.0505	2.55E+13	3699.594	3.73E+13	5416.631	5468.496	20272.07
2.12E+13	2749.881	4.38E+12	568.5572	3.21E+13	4171.628	4.48E+13	5822.349	6641.204	25103.02
2.56E+13	3006.928	5.29E+12	621.7742	3.8E+13	4461.771	5.27E+13	6185.965	7481.556	30377.94
2.73E+13	2952.254	5.71E+12	616.2912	3.65E+13	3941.563	5.29E+13	5711.447	7790.58	32693.72
2.98E+13	2988.927	5.87E+12	590.002	3.7E+13	3715.012	5.52E+13	5541.014	7844.66	36056.58
3.5E+13	3307.82	6.52E+12	616.179	3.57E+13	3375.623	5.63E+13	5320.966	7784.985	42708.34
3.86E+13	3471.665	6.79E+12	610.6761	3.64E+13	3275.738	5.93E+13	5335.493	7839.911	46839.82
4.35E+13	3741.987	7.25E+12	623.2602	3.67E+13	3156.002	6.23E+13	5357.201	7888.352	52594.46
4.97E+13	4096.55	7.8E+12	643.2102	3.7E+13	3046.912	6.53E+13	5379.852	7918.375	59785.1
5.75E+13	4552.695	8.47E+12	671.1876	3.72E+13	2948.998	6.82E+13	5402.594	7962.038	68790.86
1.52E+13	2338.436	3.07E+12	473.2591	2.31E+13	3554.893	3.53E+13	5435.19	5208.629	18070.43
1.71E+13	2481.029	3.5E+12	509.0505	2.55E+13	3699.594	3.73E+13	5416.631	5468.496	20272.07
2.12E+13	2749.881	4.38E+12	568.5572	3.21E+13	4171.628	4.48E+13	5822.349	6641.204	25103.02
2.57E+13	3016.52	5.3E+12	621.9699	3.81E+13	4478.736	5.27E+13	6192.151	7482.668	30472.08
2.83E+13	3054.405	5.78E+12	624.8581	3.88E+13	4186.93	5.54E+13	5988.598	7831.169	33600.19
3.09E+13	3107.435	5.91E+12	594.0359	4.01E+13	4025.067	5.88E+13	5908.542	7932.493	36842.2
3.36E+13	3182.02	5.89E+12	556.9503	4.16E+13	3931.809	6.32E+13	5980.584	7981.957	40068.81
3.59E+13	3226.905	5.93E+12	533.2447	4.22E+13	3795.748	6.64E+13	5972.142	8066.167	42958.65
3.9E+13	3349.306	6.12E+12	526.4127	4.26E+13	3665.096	6.97E+13	5991.725	8125.556	46725.73
4.33E+13	3566.581	6.37E+12	525.358	4.41E+13	3632.688	7.43E+13	6127.184	8211.324	51708.07
4.87E+13	3860.15	6.84E+12	541.7889	4.59E+13	3639.689	7.94E+13	6287.893	8359.974	58057.85
1.52E+13	2338.436	3.07E+12	473.2591	2.31E+13	3554.893	3.53E+13	5435.19	5208.629	18070.43
1.71E+13	2480.467	3.5E+12	508.9293	2.56E+13	3723.093	3.73E+13	5418.072	5468.341	20257.79
2.16E+13	2805.124	4.39E+12	570.2784	3.34E+13	4336.779	4.5E+13	5847.663	6643.545	25499.49
2.68E+13	3146.008	5.36E+12	629.4932	3.97E+13	4659.396	5.3E+13	6225.712	7495.633	31454.36
3.17E+13	3424.507	6.09E+12	657.3523	4.38E+13	4735.041	5.92E+13	6397.873	7888.323	36993.81
3.72E+13	3733.843	6.5E+12	652.6456	4.61E+13	4631.896	6.46E+13	6490.225	8030.021	43145.95
4.14E+13	3918.472	6.52E+12	616.3235	4.76E+13	4502.371	6.93E+13	6551.393	8095.101	47918.26
4.57E+13	4107.857	6.52E+12	586.4698	4.94E+13	4441.292	7.4E+13	6658.851	8221.48	52618.68
5.01E+13	4306.181	6.51E+12	559.5572	5.11E+13	4394.278	7.9E+13	6793.3	8337.471	57502.46
5.47E+13	4505.269	6.5E+12	535.3984	5.35E+13	4405.529	8.47E+13	6979.207	8473.564	62617.91
5.96E+13	4724.22	6.58E+12	521.4004	5.59E+13	4430.069	9.05E+13	7174.015	8670.668	68261.69
1.83E+13	2647.124	2.7E+12	391.8242	2.73E+13	3965.655	4.85E+13	7034.356		21774.74
2.58E+13	3382.464	2.77E+12	362.8974	3.26E+13	4280.812	5.85E+13	7668.824		30534.68
3.66E+13	4434.248	1.74E+12	210.5956	3.71E+13	4487.786	5.78E+13	6997.391		42948.64
4.73E+13	5396.02	1.22E+12	139.3984	4.13E+13	4707.281	6.04E+13	6893.179		55182.51
5.79E+13	6328.636	7.35E+11	80.39993	4.33E+13	4738.714	6.18E+13	6761.814		67236.75
6.72E+13	7164.145	3.76E+11	40.11658	4.39E+13	4682.628	6.29E+13	6702.482		77644.76
7.5E+13	7918.415	1.55E+11	16.37624	4.27E+13	4504.116	6.48E+13	6838.367		86294.33
8.11E+13	8561.544	4.9E+10	5.173239	3.94E+13	4158.413	6.8E+13	7183.837		93087.02
8.63E+13	9178.985	1.2E+10	1.275241	3.48E+13	3704.193	7.33E+13	7799.43		99015.45
9.27E+13	9981.105	2.16E+09	0.232104	2.99E+13	3217.881	8.25E+13	8877.379		106456.6
1.83E+13	2647.124	2.7E+12	391.8242	2.73E+13	3965.655	4.85E+13	7034.356		21774.74
2.58E+13	3382.464	2.77E+12	362.8974	3.26E+13	4280.812	5.85E+13	7668.824		30534.68
3.39E+13	4100.862	2.2E+12	266.1965	3.81E+13	4611.96	6.21E+13	7524.759		39787.96

4.27E+13	4866.564	1.74E+12	198.5713	4.29E+13	4895.518	6.55E+13	7466.871	49818.88
5.16E+13	5640.572	1.22E+12	133.4531	4.58E+13	5010.112	6.66E+13	7282.795	59913.77
5.99E+13	6392.78	7.58E+11	80.81172	4.77E+13	5089.866	6.65E+13	7088.408	69248.21
6.83E+13	7213.235	3.96E+11	41.78878	4.81E+13	5082.47	6.67E+13	7037.082	78583.35
7.53E+13	7948.865	1.69E+11	17.87757	4.65E+13	4907.886	6.76E+13	7140.04	86317.8
8.07E+13	8582.725	5.77E+10	6.142164	4.31E+13	4582.122	7.02E+13	7466.6	92352.72
8.55E+13	9204.465	1.49E+10	1.608468	3.84E+13	4128.692	7.51E+13	8078.998	97890.16
1.83E+13	2647.124	2.7E+12	391.8242	2.73E+13	3965.655	4.85E+13	7034.356	21774.74
2.58E+13	3382.464	2.77E+12	362.8974	3.26E+13	4280.812	5.85E+13	7668.824	30534.68
3.31E+13	4005.04	2.44E+12	295.1156	3.85E+13	4667.72	6.45E+13	7809.819	38892.66
4.08E+13	4651.228	2.06E+12	234.7818	4.37E+13	4982.197	6.86E+13	7830.088	47641.58
4.83E+13	5277.179	1.57E+12	171.5093	4.7E+13	5142.154	7.02E+13	7677.387	56050.92
5.53E+13	5902.291	1.09E+12	115.7439	4.96E+13	5290.663	7E+13	7468.61	63897.08
6.3E+13	6646.449	6.54E+11	69.01885	5.09E+13	5376.282	6.94E+13	7327.44	72360.04
6.57E+13	6934.81	5.21E+11	54.99807	5.29E+13	5586.718	7.11E+13	7508.503	75231.06
6.82E+13	7250.226	3.93E+11	41.77911	5.43E+13	5770.549	7.26E+13	7719.117	77866.11
7.16E+13	7702.751	2.49E+11	26.80119	5.43E+13	5842.292	7.34E+13	7899.484	81602.56
1.83E+13	2647.124	2.7E+12	391.8242	2.73E+13	3965.655	4.85E+13	7034.356	21774.74
2.58E+13	3382.464	2.77E+12	362.8974	3.26E+13	4280.812	5.85E+13	7668.824	30534.68
3.29E+13	3982.036	2.78E+12	337.0662	3.92E+13	4748.09	6.83E+13	8274.381	38727.64
3.93E+13	4485.008	2.61E+12	297.2324	4.48E+13	5108.76	7.44E+13	8492.614	46002.39
4.46E+13	4877.283	2.32E+12	253.2199	4.88E+13	5337.859	7.83E+13	8555.195	51838.17
4.87E+13	5188.893	1.98E+12	211.1889	5.26E+13	5605.158	8.02E+13	8555.108	56142.77
5.24E+13	5532.001	1.6E+12	169.1156	5.56E+13	5869.716	8.09E+13	8541.819	60098.59
5.57E+13	5875.698	1.23E+12	129.7738	5.76E+13	6080.94	8.05E+13	8499.517	63608.32
5.91E+13	6287.477	8.81E+11	93.67213	5.88E+13	6249.352	7.97E+13	8472.635	67401.37
6.29E+13	6773.608	5.87E+11	63.18185	5.92E+13	6371.888	7.88E+13	8483.114	71639.8
1.54E+13	2374.244	2.65E+12	407.3741	2.5E+13	3840.005	4.37E+13	6720.458	18628.99
1.83E+13	2647.124	2.7E+12	391.8242	2.73E+13	3965.655	4.85E+13	7034.356	21774.74
2.6E+13	3410.667	2.8E+12	366.7636	3.3E+13	4324.716	5.97E+13	7831.7	30802.54
3.32E+13	4015.954	2.81E+12	340.0462	3.94E+13	4765.787	6.89E+13	8338.779	39065.4
3.96E+13	4511.972	2.66E+12	303.0147	4.5E+13	5135.107	7.53E+13	8591.109	46290.52
4.48E+13	4893.816	2.41E+12	263.0228	4.92E+13	5374.452	7.96E+13	8702.584	52032.75
4.85E+13	5167.334	2.13E+12	227.0569	5.31E+13	5659.404	8.23E+13	8774.143	55926.61
5.16E+13	5451.945	1.82E+12	192.5134	5.64E+13	5952.551	8.39E+13	8861.413	59238.27
5.39E+13	5687.937	1.55E+12	163.1917	5.88E+13	6211.795	8.48E+13	8958.1	61561.9
5.57E+13	5920.627	1.29E+12	136.9573	6.07E+13	6458.606	8.55E+13	9094.316	63411.36
5.71E+13	6146.81	1.06E+12	114.1922	6.23E+13	6709.111	8.64E+13	9294.655	64900.67
1.49E+13	2284.569	3.06E+12	470.5786	2.41E+13	3711.251		4562.644	18397.24
1.75E+13	2537.232	2.93E+12	424.2823	2.6E+13	3770.19		4779.518	21525.02
2.44E+13	3226.889	2.97E+12	392.8322	3.79E+13	5017.071		6238.012	29194.47
2.89E+13	3593.8	2.22E+12	275.0188	4.95E+13	6149.468		8602.663	33250.03
4.01E+13	4776.737	2.05E+12	244.4565	4.74E+13	5636.219		11989.97	44555.59
6.46E+13	7534.554	4.14E+12	482.1208	4.26E+13	4963.675		16183.32	69861.17
8.94E+13	10407.38	7.19E+12	837.6354	3.83E+13	4456.608		21530.24	97000.08

1.1E+14	12961	9.92E+12	1173.256	4.07E+13	4815.213	26477.19	120805.7
1.26E+14	15403.13	1.13E+13	1377.372	4.6E+13	5613.148	34770.27	141833.4
1.44E+14	18324.62	1.16E+13	1480.939	4.94E+13	6310.395	43764.09	161861.2
1.57E+14	21258.02	1.19E+13	1607.158	5.43E+13	7359.705	54632.8	177583.5
1.49E+13	2284.569	3.06E+12	470.5786	2.41E+13	3711.251	4562.644	18397.24
1.75E+13	2537.232	2.93E+12	424.2823	2.6E+13	3770.19	4779.518	21525.02
2.44E+13	3226.889	2.97E+12	392.8322	3.79E+13	5017.071	6238.012	29194.47
3.26E+13	4045.612	2.91E+12	361.1045	5.24E+13	6508.159	8741.062	37527.81
4.28E+13	5087.473	2.96E+12	352.0571	5.73E+13	6819.66	12574.02	47472.26
5.93E+13	6909.643	2.89E+12	336.4161	6.06E+13	7058.585	17174.51	63750.05
7.9E+13	9194.584	4.42E+12	514.5474	5.71E+13	6642.869	22601.73	85194.51
1.01E+14	11890.23	7.48E+12	883.8839	5.22E+13	6171.75	27671.52	109389
1.19E+14	14454.62	1.04E+13	1270.326	5.34E+13	6510.845	36136.41	132139
1.37E+14	17526.51	1.29E+13	1651.912	5.41E+13	6906.318	45118.25	155472.3
1.51E+14	20500.96	1.42E+13	1928.815	5.86E+13	7939.743	56029.77	172583.5
1.49E+13	2284.569	3.06E+12	470.5786	2.41E+13	3711.251	4562.644	18397.24
1.75E+13	2537.232	2.93E+12	424.2823	2.6E+13	3770.19	4779.518	21525.02
2.44E+13	3226.889	2.97E+12	392.8322	3.79E+13	5017.071	6238.012	29194.47
3.41E+13	4231.855	3.37E+12	418.357	5.24E+13	6504.71	8755.365	39305.59
4.48E+13	5325.483	3.48E+12	414.5348	5.88E+13	6994.862	12683.09	49861.15
5.99E+13	6984.114	3.4E+12	396.3169	6.56E+13	7644.642	17478.64	64555.61
7.57E+13	8812.959	3.39E+12	394.2384	6.7E+13	7797.447	23078.95	81694.51
9.23E+13	10914.7	5.11E+12	603.7081	6.18E+13	7308.219	28227.32	100139
1.13E+14	13743.24	7.87E+12	959.3504	6.09E+13	7422.093	36794.54	122777.9
1.31E+14	16707.12	1.14E+13	1450.788	6.08E+13	7768.278	45999.27	144944.6
1.45E+14	19615.83	1.44E+13	1945.764	6.31E+13	8553.679	57033.44	163194.6
1.49E+13	2284.569	3.06E+12	470.5786	2.41E+13	3711.251	4562.644	18397.24
1.75E+13	2537.232	2.93E+12	424.2823	2.6E+13	3770.19	4779.518	21525.02
2.44E+13	3226.889	2.97E+12	392.8322	3.79E+13	5017.071	6238.012	29194.47
3.43E+13	4259.447	3.4E+12	422.4957	5.25E+13	6521.954	8761.629	39555.59
4.51E+13	5361.846	3.95E+12	470.4012	5.96E+13	7094.033	12719.24	50250.04
5.94E+13	6922.594	4.39E+12	512.2331	6.86E+13	8000.809	17596.93	64055.61
7.31E+13	8505.718	4.14E+12	482.2063	7.45E+13	8670.658	23348.07	78833.4
8.7E+13	10290.63	4.23E+12	499.5865	7.3E+13	8631.909	28665.14	94277.85
1.03E+14	12598.25	5.09E+12	620.2579	7.54E+13	9190.387	37538.67	112139
1.18E+14	15110.9	6.68E+12	853.0917	7.63E+13	9744.045	47148.37	128611.2
1.28E+14	17318.28	7.91E+12	1072.317	8.18E+13	11088.52	58687.56	139250.1
1.49E+13	2284.569	3.06E+12	470.5786	2.41E+13	3711.251	4562.644	18397.24
1.75E+13	2537.232	2.93E+12	424.2823	2.6E+13	3770.19	4779.518	21525.02
2.44E+13	3226.889	2.97E+12	392.8322	3.79E+13	5017.071	6238.012	29194.47
3.54E+13	4390.507	3.48E+12	431.463	5.33E+13	6615.076	8770.579	40833.37
4.76E+13	5659.359	4.28E+12	509.4084	6.19E+13	7371.712	12792.26	53111.15
6.09E+13	7103.916	5.24E+12	610.6648	7.31E+13	8518.871	17774.08	65888.94
7.05E+13	8211.414	5.86E+12	682.3979	8.29E+13	9647.36	23643.05	76416.73
8.01E+13	9469.481	5.94E+12	702.5744	8.57E+13	10136.25	29048.21	87111.18
9.3E+13	11338.08	5.6E+12	683.2661	9.01E+13	10992.56	37993.96	101027.9
1.08E+14	13805.54	5.41E+12	690.9865	8.92E+13	11389.93	47585.07	117194.5

1.18E+14	15969.88	5.66E+12	767.6089	9.31E+13	12617.71	59163.59	128000.1
1.49E+13	2284.569	3.06E+12	470.5786	2.41E+13	3711.251	4562.644	18397.24
1.75E+13	2537.232	2.93E+12	424.2823	2.6E+13	3770.19	4779.518	21525.02
2.49E+13	3298.246	2.93E+12	388.0506	3.8E+13	5035.462	6236.758	29750.02
3.56E+13	4424.996	3.48E+12	432.4977	5.4E+13	6704.748	8765.831	41194.48
4.96E+13	5900.675	4.49E+12	534.5317	6.41E+13	7632.862	12816.85	55666.71
6.49E+13	7560.457	5.54E+12	645.9577	7.69E+13	8965.699	17869.22	70416.72
7.61E+13	8864.705	5.95E+12	692.7471	9.04E+13	10527.04	23856.1	82694.51
8.58E+13	10139.54	5.89E+12	696.6621	9.91E+13	11716.14	29372.12	93333.41
9.57E+13	11670.06	5.68E+12	692.0737	1.12E+14	13614.51	38463.41	104139
1.06E+14	13532.41	5.73E+12	731.0694	1.15E+14	14642.67	48129.23	115194.5
1.14E+14	15514.14	6.08E+12	823.7295	1.17E+14	15864.42	59647.46	124666.8

Secondary electricity, kWh	Secondary electricity (biomass)	Secondary electricity (biomass CCS)	Secondary electricity (coal)	Secondary electricity (coal CCS)	Secondary electricity (gas)	Secondary electricity (gas CCS)	Secondary electricity (geothermal)	Secondary electricity (hydro)	Secondary electricity (renewables excl. bio)
1.82E+13	220.7747	0	7248.086	0	3659.013	0		2931.677	3098.927
2.13E+13	337.5229	0	8598.18	0	4721.203	0		3440.925	3884.651
2.41E+13	590.5518	1.691102	7659.459	2.005331	6051.049	64.02549		4400.892	6275.659
2.26E+13	1424.46	388.0921	2389.521	17.12421	6910.707	451.667		4935.918	7578.488
2.75E+13	1950.284	1850.351	701.0448	361.254	4179.544	2213.776		5947.516	18310.6
3.53E+13	2200.792	2152.8	843.6452	761.9188	3270.78	2982.81		5483.807	27915.25
4.25E+13	2972.93	2965.848	1217.286	1216.945	4258.255	4192.274		5231.179	33147.52
4.87E+13	3986.174	3986.167	1736.142	1736.142	6384.864	6204.566		5738.335	35662.13
5.23E+13	4444.47	4444.466	1634.224	1634.223	5725.751	5457.803		6130.361	39272.95
5.26E+13	4555.406	4554.318	1108.42	1108.419	3587.769	3386.83		6194.5	41828.41
5.03E+13	5066.722	5064.533	567.2509	567.2504	2824.377	2418.287		6056.463	40514.62
1.82E+13	220.7747	0	7248.086	0	3659.013	0		2931.677	3098.927
2.13E+13	337.5229	0	8598.181	0	4721.204	0		3440.925	3884.651
2.68E+13	282.6268	0	9797.712	0	6553.67	0		4556.901	6324.403
3.32E+13	349.9675	0.021438	8994.818	430.9574	10282.6	185.7103		5383.296	9816.821
3.86E+13	604.5869	376.4895	7189.742	1649.656	11276.27	959.682		5999.935	16883.14
4.38E+13	1306.503	1184.511	4788.247	2284.781	9709.737	1415.349		6230.208	26843.84
4.98E+13	2554.962	2473.795	3827.251	3479.283	7446.296	1735.045		6429.991	35140.68
5.34E+13	2977.639	2958.792	4153.845	4119.203	5243.627	2171.934		6325.502	40427.96
5.57E+13	3777.685	3776.385	3974.728	3968.477	4518.927	2732.195		6301.908	42897.89
5.54E+13	3801.057	3800.733	3799.897	3796.19	4701.23	3097.692		6765.514	42369.18
5.92E+13	2691.831	2691.18	2775.39	2773.03	5243.972	3143.19		6961.117	47834.12
1.82E+13	220.7747	0	7248.086	0	3659.013	0		2931.677	3098.927
2.13E+13	337.5229	0	8598.181	0	4721.204	0		3440.925	3884.651
2.75E+13	286.0853	0	10262.82	0	6681.725	0		4598.673	6361.318
3.59E+13	281.2452	0	11682.9	0	10974.07	0		5385.526	9245.662
4.39E+13	164.7051	0	12504.78	1.7188	13668.05	0		6049.594	15119.81
5.1E+13	111.0696	0.131225	10707.05	149.0949	14153.74	0		6255.683	25088.23
5.74E+13	87.56099	6.491105	8880.05	852.5055	13752.29	39.66548		6488.066	34040.48
6.09E+13	100.6978	48.09954	7707.262	2188.942	9928.461	294.3487		6624.78	42751.75
6.2E+13	678.0674	657.956	6429.283	3592.17	6986.804	629.9171		6678.28	47652.62
6.08E+13	2533.514	2520.881	5117.421	4086.57	5427.247	1269.352		6875.217	47418.25
6.07E+13	2410.112	2403.134	4560.338	3996.248	5554.299	1520.088		7019.072	47877.7
1.82E+13	220.7747	0	7248.086	0	3659.013	0		2931.677	3098.927
2.13E+13	337.5229	0	8598.181	0	4721.204	0		3440.925	3884.651
2.75E+13	290.4782	0	10285.93	0	6699.805	0		4598.912	6360.015
3.64E+13	204.9365	0	12344.12	0	11063.57	0		5386.782	9094.41
4.6E+13	106.9587	0	15204.43	0	14148.5	0		6051.113	14175.72
5.49E+13	64.02424	0	16041.59	0	15193.94	0		6272.705	22722.56

6.25E+13	28.94641	0	16040.14	0	15427.03	0		6497.588	30461.77
6.76E+13	31.6211	0	14056.36	10.86542	13285.91	0		6706.489	39963.88
7.01E+13	26.92196	0.243417	10975.93	332.1368	11073.58	1.499665		6833.006	47904.96
7E+13	26.06968	5.549256	8594.95	841.0416	9993.902	10.60778		6969.508	51298.89
6.91E+13	29.37204	15.5708	6532.683	1134.623	10450.65	12.32304		7163.386	51954.24
1.82E+13	220.7747	0	7248.086	0	3659.013	0		2931.677	3098.927
2.13E+13	337.5229	0	8598.181	0	4721.204	0		3440.925	3884.651
2.75E+13	295.4377	0	10294.84	0	6691.541	0		4599.779	6360.217
3.65E+13	269.1332	0	12499.31	0	10976.07	0		5386.874	9051.183
4.66E+13	116.3887	0	15936.49	0	14243.73	0		6051.11	13965.58
5.57E+13	64.24634	0	17402.8	0	15278.12	0		6276.297	22045.46
6.41E+13	34.38261	0	18746.66	0	15789.26	0		6496.944	29043.49
7.14E+13	20.46903	0	19601.2	0	14168.06	0		6720.491	37396.36
7.65E+13	6.87455	0	17875.14	0	12282.04	0		6871.064	46286.1
7.84E+13	4.675817	0	15984	0	12051.7	0		7030.225	50319.66
7.76E+13	3.402284	0	13909.07	0	13084.64	0		7301.445	50564.1
1.81E+13	125.8334	0	7312.506	0	3690.559	0	56.66671	2946.113	3113.336
2.1E+13	212.5002	0	8618.34	0	4535.004	0	98.05563	3576.392	4203.614
2.63E+13	461.1115	0	8568.34	0	6958.339	0	88.61118	4267.781	6653.061
3.16E+13	230.0002	17.77779	1286.945	376.9447	9736.397	1383.89	211.9446	5970.005	14918.07
4.46E+13	411.3892	229.4446	527.7782	526.1115	7903.062	5404.449	652.5005	7799.451	26979.19
6.24E+13	1128.89	936.3896	278.0558	276.3891	6828.894	6031.671	992.5008	8609.729	38257.81
8.3E+13	1645.835	1372.501	178.3335	178.3335	4916.671	4179.17	1317.779	9399.452	49693.65
1.01E+14	1609.724	1441.39	86.11118	86.11118	2598.058	2208.335	1628.89	9977.508	64567.83
1.14E+14	1716.946	1653.612	21.66668	21.66668	724.1672	615.556	1672.501	10242.79	78303.95
1.25E+14	1364.168	1319.168	4.16667	4.16667	0.555556	0.555556	1718.89	10421.4	94177.85
1.38E+14	1206.668	1170.556	0.277778	0.277778	0.277778	0.277778	1748.613	10539.18	115878.1
1.81E+13	125.8334	0	7310.561	0	3693.059	0	56.66671	2945.558	3113.891
2.1E+13	219.1668	0	8592.785	0	4557.781	0	98.05563	3575.558	4203.892
2.64E+13	468.0559	0	8521.951	0.277778	7015.839	18.33335	88.61118	4267.226	6648.894
3.24E+13	315.5558	9.72223	4150.003	129.1668	12089.18	1090.834	52.22226	5359.171	10723.06
4E+13	83.61118	36.94447	1442.223	500.556	15755.01	4829.171	87.22229	6021.949	15440.85
5.16E+13	174.7224	112.7779	1006.39	1005.834	16174.46	12335.84	151.6668	7393.061	22380.57
6.49E+13	435.2781	381.3892	1110.279	1109.723	15115.57	13710.57	231.1113	8125.007	30012.25
8.06E+13	1026.945	978.0563	1065.556	1065.556	11768.34	10226.67	409.4448	9145.285	41230.03
9.66E+13	1298.89	1271.39	735.5561	735.5561	7223.895	6140.283	849.7229	9863.619	57400.05
1.17E+14	1416.668	1375.557	620.8338	620.8338	4309.448	3663.058	1297.779	10396.4	79242.56
1.4E+14	1309.168	1278.334	481.3893	481.3893	1391.946	1183.057	1686.946	10535.29	106921.8
1.81E+13	125.8334	0	7310.561	0	3693.059	0	56.66671	2945.558	3113.891
2.1E+13	219.1668	0	8592.785	0	4557.781	0	98.05563	3575.558	4203.892
2.64E+13	463.6115	0	8617.785	0.277778	6905.839	9.72223	88.61118	4244.17	6615.005
3.22E+13	359.7225	3.333336	7125.839	11.11112	11945.29	9.72223	52.50004	4766.115	9019.452
3.87E+13	192.2224	17.77779	3360.003	114.4445	17317.79	316.9447	8.611118	5940.283	13511.96
4.75E+13	255.8335	70.55561	897.2229	331.1114	21151.96	1448.89	58.0556	6376.672	18520.85
5.96E+13	409.167	245.8335	880.834	759.7228	20596.13	5661.393	122.2223	7497.784	25650.3
7.05E+13	631.6672	626.1116	916.6674	916.6674	15730.85	12483.62	199.4446	8322.784	32274.75
8.44E+13	947.7785	943.0563	1063.334	1063.334	14141.12	13326.12	345.0003	9012.785	40142.53

1.02E+14	1196.112	1181.945	967.5008	967.5008	11258.62	10202.79	609.4449	9917.508	56272.55
1.21E+14	1345.279	1323.89	1036.112	1036.112	6845.561	5818.616	1107.779	10352.51	75690.34
1.81E+13	125.8334	0	7310.561	0	3693.059	0	56.66671	2945.558	3113.891
2.1E+13	219.1668	0	8592.785	0	4557.781	0	98.05563	3575.558	4203.892
2.63E+13	463.0559	0	8638.062	0	7015.561	0	88.61118	4244.17	6438.338
3.23E+13	333.3336	1.111112	7480.562	4.16667	12156.12	0	50.27782	4696.393	8839.729
3.87E+13	131.6668	5.55556	4726.393	21.94446	18010.57	0	6.388894	5748.893	12464.73
4.7E+13	82.22229	23.33335	3206.947	68.33339	22761.41	0	6.388894	6057.227	16181.12
5.86E+13	134.1668	72.77784	2621.669	163.0557	25982.8	79.72229	3.888892	6434.45	21982.8
6.98E+13	227.778	195.0002	1531.112	314.1669	25139.74	629.1672	3.611114	7122.228	28325.3
8.02E+13	450.0004	448.3337	527.5004	527.5004	20442.79	3561.67	21.94446	8229.173	34250.58
9.3E+13	706.3895	705.2783	841.6673	841.6673	11993.62	8883.063	156.9446	9525.285	43017.53
1.09E+14	935.0007	933.8896	1278.612	1278.612	10248.34	9586.674	343.6114	9910.563	54616.15
1.81E+13	125.8334	0	7310.561	0	3693.059	0	56.66671	2945.558	3113.891
2.1E+13	219.1668	0	8592.785	0	4557.781	0	98.05563	3575.281	4203.614
2.63E+13	471.9448	0	8659.451	0	7096.395	0	88.88896	4180.837	6340.005
3.25E+13	332.2225	0	8245.284	0	12310.57	0	45.55559	4639.448	8383.896
3.9E+13	199.7224	0	7210.561	0	18007.79	0	3.333336	5650.838	11324.45
4.72E+13	376.667	0	7340.839	0	23130.02	0	3.333336	5863.06	14389.18
5.89E+13	410.0003	0	8593.618	5.277782	27489.74	0	1.944446	6127.505	19054.74
7.11E+13	478.6115	0	8911.396	33.88892	30860.86	0	1.111112	6480.839	24866.69
8.15E+13	900.5563	0.277778	6754.728	116.1112	31343.64	0	1.111112	6741.672	30905.58
9.21E+13	1162.779	3.888892	4409.448	298.3336	31432.25	0	1.111112	7040.561	36926.7
1.04E+14	1602.501	15.55557	1334.168	481.9448	29607.25	0	0.833334	9180.285	42821.98
1.81E+13	125.8334	0	7310.561	0	3692.781	0	56.66671	2945.28	3113.614
2.1E+13	219.1668	0	8593.062	0	4557.504	0	98.05563	3575.281	4203.614
2.63E+13	471.9448	0	8876.952	0	7099.172	0	88.88896	4243.892	6301.672
3.27E+13	338.0558	0	8971.674	0	12163.62	0	44.1667	4695.004	8036.395
3.9E+13	230.278	0	9048.618	0	17310.57	0	0	5274.171	10309.73
4.73E+13	450.0004	0	10288.06	0	22541.68	0	0	5425.56	12548.9
5.89E+13	432.5003	0	13201.68	0	27015.02	0	0	5646.949	16316.4
7.18E+13	510.8337	0	16091.68	0	30594.47	0	0	6151.394	21334.46
8.24E+13	908.0563	0	19194.74	0	31508.91	0	0	6599.728	24613.08
9.32E+13	1221.668	0	19606.13	0	31691.14	0	0	6855.005	29538.36
1.05E+14	1596.112	0	17395.01	0	34126.42	0	0	6925.283	36363.92
1.81E+13	377.1947	0	7025.922	0	3706.531	0	53.94449	2895.725	3064.308
2.03E+13	377.0559	0	8193.284	0	4054.087	0	56.36116	3318.447	3535.531
2.51E+13	421.2781	0	10021.26	0	4820.726	0	66.72228	4266.253	4709.948
2.97E+13	534.7782	0	9808.202	0	5502.366	0	77.00006	5254.754	6894.95
3.3E+13	2333.335	451.6948	5710.532	1372.89	5320.032	1287.223	88.63896	7106.811	11703.98
3.93E+13	6169.56	3503.253	5890.532	3782.586	5023.337	3216.53	98.55563	7559.034	15205.79
4.59E+13	9129.507	7302.173	6800.505	5780.449	4919.476	4181.559	107.2779	7829.673	19159.6
5.47E+13	13783.23	11244.18	5494.671	4670.476	4486.42	3813.447	115.7779	8562.951	25465.74
6.35E+13	16816.37	13815.65	4486.754	3813.753	4045.531	3438.725	123.9445	8831.646	32767.25
7.28E+13	19390.27	16000.29	3598.281	3058.53	3384.614	2876.919	132.0557	8831.646	41331.03
8.24E+13	21325.93	17643.15	2851.808	2424.03	2801.558	2381.335	140.8334	8831.646	50648.37
1.81E+13	377.1947	0	7025.922	0	3706.531	0	53.94449	2895.725	3064.308

2.03E+13	377.0559	0	8193.284	0	4054.087	0	56.36116	3318.447	3535.531
2.51E+13	421.2781	0	10021.26	0	4820.726	0	66.72228	4266.253	4709.948
3.04E+13	490.0559	0	11216.26	0	5237.476	0	75.75006	5252.199	6464.394
3.27E+13	1367.529	0	8701.368	670.1116	5390.754	0	85.44451	6609.894	9341.007
3.61E+13	4423.309	371.1114	7523.7	3480.308	4738.865	1279.501	95.13897	7350.728	12140.51
4.27E+13	9122.063	4193.309	7351.367	6143.644	4084.614	2736.697	103.8056	7861.84	15774.35
4.68E+13	10627.18	8607.812	7489.867	6366.394	4143.976	3522.364	112.2779	8232.368	18837.49
5.26E+13	12802.95	10450.23	7679.645	6527.7	4120.253	3502.197	120.4723	8496.59	22616.71
5.98E+13	15178.04	12465.26	7438.117	6322.394	3995.809	3396.447	128.6112	8710.563	28016.08
6.88E+13	18061.85	14913.32	6510.116	5533.588	3717.336	3159.753	137.4446	8831.646	35349.58
1.81E+13	377.1947	0	7025.922	0	3706.531	0	53.94449	2895.725	3064.308
2.03E+13	377.0559	0	8193.284	0	4054.087	0	56.36116	3318.447	3535.531
2.51E+13	421.2781	0	10021.26	0	4820.726	0	66.72228	4266.253	4709.948
3.05E+13	485.5837	0	11365.37	0	5214.56	0	75.41673	5252.032	6438.477
3.36E+13	1231.751	0	10870.48	4.388892	5401.865	0	83.8334	6212.366	8556.118
3.68E+13	3655.031	0	10665.18	505.1671	5232.06	0	92.66674	6937.561	10672.06
4.01E+13	6355.616	0	11212.79	900.6674	4805.004	0	101.139	7138.589	12311.65
4.3E+13	9483.563	0	9813.869	3185.78	4266.253	213.3057	109.5834	7653.562	14579.29
4.67E+13	11483.68	549.6949	9747.258	6304.005	3753.059	1219.057	117.7501	7999.118	17363.6
5.17E+13	13134.7	2447.058	11005.73	9354.869	3506.058	1690.89	125.9723	8180.757	20153.21
5.81E+13	15621.18	4999.337	12258.65	10419.84	3306.614	2241.807	134.8334	8250.951	23334.41
1.81E+13	377.1947		7025.922		3706.531		53.94449	2895.725	3064.308
2.03E+13	377.0559		8257.423		4058.837		56.38893	3285.558	3502.781
2.55E+13	419.3059		11090.79		4805.337		67.25005	4064.031	4349.587
3.15E+13	474.5282		14671.01		5765.81		78.19451	4611.67	4991.671
3.7E+13	590.1116		18378.32		6455.061		89.13896	5355.893	5852.616
4.31E+13	876.2229		22649.91		7146.645		99.16675	6515.283	7136.589
4.79E+13	1264.001		26533.52		7286.561		108.2223	7276.45	8079.312
5.26E+13	1793.863		30846.55		7034.839		117.0834	7567.589	8582.59
5.75E+13	2322.891		35295.14		6722.561		125.7223	7839.09	9166.702
6.26E+13	2705.002		40001.64		6438.227		134.389	8000.423	9687.674
6.83E+13	3215.03		45130.7		6165.394		143.8057	8046.701	10185.65
2.18E+13	219.2355	0	8851.565	0	5099.782	0	68.09047	3441.928	3885.209
3.05E+13	387.1764	16.10508	12098.05	69.61463	7430.789	147.7737	469.7754	3616.626	6168.852
4.29E+13	1403.754	991.2701	8750.524	4143.541	8510.146	2467.423	1167.688	3795.765	11726.16
5.52E+13	2466.997	2316.027	7575.621	6841.286	8761.874	5068.132	1430.434	4058.205	16951.54
6.72E+13	3801.782	3781.28	7518	7456.047	8535.399	7263.131	1565.785	4403.956	22163.32
7.76E+13	5106.388	5104.963	6530.437	6525.892	8592.717	8428.123	1621.388	4749.599	26302.74
8.63E+13	6260.146	6260.085	4406.169	4406.068	7769.967	7749.748	1639.748	5094.836	31341.02
9.31E+13	7448.366	7448.364	1638.411	1638.41	5632.183	5615.573	1623.497	5441.199	37026.74
9.9E+13	9280.589	9280.589	354.5804	354.5804	3226.091	3210.286	1612.51	5786.946	45173.37
1.06E+14	15451.55	15451.55	60.05052	60.05052	1051.182	1041.388	1265.839	5959.822	50866.17
2.18E+13	219.2357	0	8851.565	0	5099.782	0	68.09053	3441.928	3885.209
3.05E+13	387.1765	16.10515	12098.05	69.61465	7430.789	147.7737	469.7754	3616.626	6168.852
3.98E+13	775.3556	191.791	12208.5	1239.289	8691.784	1033.411	978.2611	3795.765	9686.158

4.98E+13	1319.627	733.1452	9533.9	3548.365	9428.595	2465.919	1282.377	4058.205	14564.38
5.99E+13	2118.197	1817.735	7093.653	5716.497	9196.849	4327.755	1456.892	4403.956	19841.83
6.92E+13	3082.727	3016.392	6458.481	6306.367	7961.908	6137.644	1546.93	4749.703	24850.26
7.86E+13	4313.255	4306.925	5640.559	5632.769	7189.472	6869.043	1561.718	5095.296	29411.76
8.63E+13	5450.96	5450.718	4442.959	4442.775	6585.706	6547.896	1521.411	5441.199	33729.41
9.24E+13	6487.219	6487.213	2118.904	2118.9	5068.597	5050.732	1477.904	5786.946	40148.88
9.79E+13	8077.171	8077.17	520.8316	520.8316	3115.661	3100.921	1398.719	5959.822	47834.02
2.18E+13	219.2357	0	8851.565	0	5099.782	0	68.09053	3441.928	3885.209
3.05E+13	387.1765	16.10515	12098.05	69.61465	7430.789	147.7737	469.7754	3616.626	6168.852
3.89E+13	674.4229	86.1546	13126.78	584.971	8887.909	686.4759	899.1416	3795.765	9002.652
4.76E+13	1025.062	275.3962	12302.61	1627.682	9729.048	1475.032	1157.488	4058.205	12882.94
5.61E+13	1459.29	789.6089	9348.662	3421.148	9915.125	2603.943	1337.083	4403.956	17606.35
6.39E+13	2020.774	1666.006	6562.178	4883.515	8493.513	4112.905	1475.188	4749.703	23200.4
7.24E+13	2913.208	2823.853	5480.565	5314.427	6981.686	5274.827	1522.486	5095.449	28294.21
7.52E+13	3162.278	3110.164	4830.65	4757.693	6325.379	5346.613	1391.703	5415.435	30148.63
7.79E+13	3432.781	3406.419	4468.341	4443.793	5665.795	5187.022	1273.387	5786.946	32335.9
8.16E+13	3925.137	3919.447	3730.861	3727.169	4879.808	4721.519	1204.465	5959.822	36910.03
2.18E+13	219.2357	0	8851.565	0	5099.782	0	68.09053	3441.928	3885.209
3.05E+13	387.1765	16.10515	12098.05	69.61465	7430.789	147.7737	469.7754	3616.626	6168.852
3.87E+13	598.0706	33.21328	14306.74	199.5145	9242.901	414.3176	810.7903	3795.765	8351.13
4.6E+13	827.7225	58.79766	15123.12	349.7812	10369.53	690.2669	990.6374	4058.205	11042.94
5.18E+13	1030.743	90.76764	15207.27	512.6693	11018.96	936.0508	1057.927	4403.956	13506.28
5.61E+13	1196.174	127.5328	15104.65	641.6572	9776.681	1186.072	1101.617	4749.703	16593.68
6.01E+13	1323.897	175.6812	14730.88	777.6026	8469.005	1236.969	1129.148	5095.449	19648.48
6.36E+13	1372.213	276.7975	11160.51	1045.26	7697.961	1414.241	1203.616	5441.199	24149.91
6.74E+13	1358.938	462.2371	7259.085	1407.141	6851.738	1707.83	1224.087	5786.946	29450.69
7.16E+13	1335.447	819.4257	3516.147	1851.386	5957.455	2205.975	1192.915	5959.822	35677.9
1.86E+13	142.5806	0	7484.868	0	4020.804	0	58.20096	2933.274	3099.994
2.18E+13	219.2357	0	8851.565	0	5099.782	0	68.09053	3441.928	3885.209
3.08E+13	368.2873	0	12485.38	0	7693.43	0	453.3049	3616.626	5968.163
3.91E+13	581.0001	0	14807.67	0	9496.692	0	787.0885	3795.765	8166.085
4.63E+13	787.8785	0	15825.5	0	10762.64	0	956.7709	4058.205	10702.96
5.2E+13	962.4356	0	16169.4	0	11566.52	0	1012.887	4403.956	13009.09
5.59E+13	1105.801	0	16335.46	0	10509.02	0	1039.765	4749.703	15647.65
5.92E+13	1236.26	0	16468.2	0	9235.78	0	1034.629	5095.449	18092
6.16E+13	1294.204	0	13751.89	0	8709.46	0	1063.596	5441.199	21361.13
6.34E+13	1280.409	0	11783.17	0	8193.442	0	1045.101	5786.946	24441.55
6.49E+13	1185.687	0	10185.39	0	8134.335	0	992.6888	5959.822	27340.7
1.84E+13	96.38897	0	7419.45	0	3805.559	0	60.91672	2969.447	3138.891
2.15E+13	139.4723	0	8505.562	0	5152.782	0	91.02785	3144.447	3786.114
2.92E+13	184.0557	0.083333	8488.896	0.222222	11444.45	0.083333	112.8056	2988.891	4888.893
3.33E+13	490.5559	307.2225	4255.559	0.305556	14441.68	275.778	262.2224	3686.114	7858.34
4.46E+13	3091.669	2952.78	878.0563	0.333334	8883.34	1625.557	337.2225	7633.339	20308.35
6.99E+13	6316.672	6247.227	3.944448	0.277778	4672.226	1988.057	340.5558	10950.01	42777.81
9.7E+13	7533.339	7511.117	1.583335	0.25	2760.558	2015.002	333.3336	12011.12	68083.39

1.21E+14	8350.007	8344.451	0.444445	0.222222	1697.501	1397.501	317.5003	12402.79	90750.07
1.42E+14	9113.896	9108.341	0.555556	0.222222	623.0561	490.2782	311.3891	12733.34	112416.8
1.62E+14	9294.452	9291.674	0.583334	0.222222	293.8891	198.0279	309.7225	13027.79	133611.2
1.78E+14	9305.563	9302.785	0.527778	0.222222	96.02785	22.44446	311.1114	13230.57	150750.1
1.84E+13	96.38897	0	7419.45	0	3805.559	0	60.91672	2969.447	3138.891
2.15E+13	139.4723	0	8505.562	0	5152.782	0	91.02785	3144.447	3786.114
2.92E+13	184.0557	0.083333	8488.896	0.222222	11444.45	0.083333	112.8056	2988.891	4888.893
3.75E+13	318.6114	52.44449	4611.115	1.222223	21275.02	590.2783	224.7224	3169.447	6166.672
4.75E+13	1011.39	588.6116	1219.445	4.333337	25872.24	6336.116	306.1114	4994.448	11241.68
6.38E+13	2802.78	2427.224	14.19446	5.361115	23777.8	12822.23	333.3336	8391.673	23888.91
8.52E+13	4866.671	4566.67	7.19445	4.888893	19011.13	14080.57	342.2225	10758.34	43805.59
1.09E+14	5733.338	5525.004	3.944448	3.750003	14311.12	12036.12	338.3336	11980.57	69111.17
1.32E+14	6566.672	6450.005	2.027779	1.694446	7172.228	6494.45	333.6114	12336.12	97222.3
1.55E+14	8091.673	7897.229	0.694445	0.333334	3027.78	2739.724	324.1669	12513.9	124722.3
1.73E+14	9247.23	8911.118	0.527778	0.222222	1561.668	1405.834	318.0558	12663.9	144250.1
1.84E+13	96.38897	0	7419.45	0	3805.559	0	60.91672	2969.447	3138.891
2.15E+13	139.4723	0	8505.562	0	5152.782	0	91.02785	3144.447	3786.114
2.92E+13	184.0557	0.083333	8488.896	0.222222	11444.45	0.083333	112.8056	2988.891	4888.893
3.93E+13	262.2224	19.83335	5405.56	26.63891	23297.24	427.5003	213.2502	3002.78	5652.782
4.99E+13	553.056	197.9446	2146.113	162.9446	32750.03	5341.671	286.6669	4027.781	8219.451
6.46E+13	1145.279	741.6673	682.5005	273.028	37583.36	18475.01	316.9447	6533.339	15650.01
8.17E+13	2321.669	1978.89	283.3336	267.2502	35583.36	23963.91	333.3336	9261.119	30055.58
1E+14	3569.447	3311.114	223.0557	222.8057	27391.69	22175.02	342.2225	10994.45	51694.49
1.23E+14	4808.337	4669.448	131.4445	131.139	17019.46	14916.68	342.2225	12008.34	80583.4
1.45E+14	6550.005	6516.672	48.94448	48.61115	7594.451	6838.894	338.0558	12319.45	110194.5
1.63E+14	7730.562	7725.006	43.69448	43.4167	4513.893	4180.559	342.2225	12452.79	132361.2
1.84E+13	96.38897	0	7419.45	0	3805.559	0	60.91672	2969.447	3138.891
2.15E+13	139.4723	0	8505.562	0	5152.782	0	91.02785	3144.447	3786.114
2.92E+13	184.0557	0.083333	8488.896	0.222222	11444.45	0.083333	112.8056	2988.891	4888.893
3.96E+13	294.4447	15.3889	5763.894	58.72227	23275.02	235.2502	209.6668	2972.225	5600.004
5.03E+13	757.7784	153.1668	3163.891	472.2226	32722.25	2733.613	280.278	3830.559	7658.339
6.41E+13	1582.501	605.8338	2360.835	1353.057	37833.36	10938.9	311.1114	5980.56	13125.01
7.88E+13	2517.224	1506.946	1921.946	1793.613	37583.36	18616.68	328.0558	8550.007	23636.13
9.43E+13	3261.114	2368.891	1859.724	1858.89	33111.14	20044.46	339.4447	10105.56	39638.92
1.12E+14	3558.336	2944.447	1843.89	1843.613	26155.58	17605.57	342.2225	11272.23	61972.27
1.29E+14	3619.447	3325.003	1970.557	1970.279	18425.01	13872.23	338.3336	11938.9	85666.74
1.39E+14	3516.669	3363.892	2443.335	2443.058	13500.01	11402.79	342.2225	12197.23	102333.4
1.84E+13	96.38897	0	7419.45	0	3805.559	0	60.91672	2969.447	3138.891
2.15E+13	139.4723	0	8505.562	0	5152.782	0	91.02785	3144.447	3786.114
2.92E+13	184.0557	0.083333	8488.896	0.222222	11444.45	0.083333	112.8056	2988.891	4888.893
4.08E+13	260.028	2.250002	8188.895	14.50001	22897.24	6.888894	193.4168	2844.447	5272.226
5.31E+13	542.7782	20.50002	7744.451	158.7779	34361.14	107.139	256.1946	3150.003	6016.671
6.59E+13	1143.89	81.05562	7125.006	701.3895	42694.48	710.0006	298.8891	4483.337	8744.451
7.64E+13	1934.446	189.6113	6458.339	1758.335	43277.81	2729.447	321.3891	6833.339	14950.01
8.71E+13	2587.224	336.3892	5227.782	2750.836	37583.36	5658.338	334.7225	8766.674	26447.24
1.01E+14	2911.113	525.2782	4277.781	3480.558	29638.91	7827.784	342.2225	10088.9	43388.92
1.17E+14	3047.225	777.2228	4333.337	4244.448	21852.8	7708.34	340.2781	11275.01	65138.94

1.28E+14	3327.78	1040.556	4380.559	4372.226	14102.79	5383.338	342.2225	12183.34	85055.62
1.84E+13	96.38897	0	7419.45	0	3805.559	0	60.91672	2969.447	3138.891
2.15E+13	139.4723	0	8505.562	0	5152.782	0	91.02785	3144.447	3786.114
2.98E+13	177.7779	0	10330.56	0	10308.34	0	100.3334	2936.113	4750.004
4.12E+13	237.7502	0	14594.46	0	17905.57	0	139.389	2641.669	4661.115
5.57E+13	474.7226	0	21363.91	0	26491.69	0	182.3057	2461.669	4355.559
7.04E+13	908.8896	0	28750.02	0	32888.92	0	246.3613	2755.28	5413.893
8.27E+13	1391.668	0	35805.58	0	35305.58	0	281.1113	3888.892	8466.673
9.33E+13	1925.279	0	40861.14	0	35722.25	0	303.8891	5775.005	13397.23
1.04E+14	2472.78	0	42666.7	0	34972.25	0	322.778	7852.784	21350.02
1.15E+14	2966.669	0	40916.7	0	31833.36	0	333.0558	9100.007	34138.92
1.25E+14	3383.336	0	36472.25	0	25583.35	0	342.2225	9997.23	50111.15

Secondary electricity (nuclear)	Secondary electricity (oil)	Secondary electricity (solar)	Secondary electricity (wind)	Secondary electricity (gas)	Secondary electricity (heat)	Secondary electricity (heat, kWh)	Secondary electricity (heat, hydro)	Secondary electricity (hydrogen)	Secondary electricity (biofuels)
2767.954	1169.036	4.572004	103.8741	14632.81				2.06E-06	310.3908
2756.29	970.6147	33.72603	341.3472	15088.05				0.000467	450.9987
2853.655	714.718	501.432	1274.182	16039.61				4.130446	604.8693
3003.408	1270.106	894.0599	1580.499	15204.95				1952.01	3257.076
2227.568	108.0643	7705.728	4643.847	15747.12				11149.98	5402.312
1016.863	19.6495	14550.4	8976.504	15049.48				15180.77	6619.99
871.7987	17.21555	20102.12	9079.61	13186.74				15075.55	7881.239
960.1889	20.2861	24064.44	6949.914	10885.3				15191.19	8979.176
1182.995	19.10052	27538.17	7144.408	8630.86				16417.24	9301.824
1464.955	15.01467	29251.03	8525.601	7354.334				18611.88	8693.829
1359.365	11.68999	28607.46	7745.816	6714.7				21688.68	7742.769
2767.954	1169.036	4.572004	103.8741	14632.81				2.06E-06	310.3908
2756.29	970.6148	33.72603	341.3472	15088.04				0.000467	450.9987
2919.105	925.7539	443.5454	1217.251	18417.54				3.38498	587.2743
3060.619	670.252	1573.757	2573.899	23071.78				246.1763	1214.938
2363.34	310.4542	5877.013	4507.725	27958.41				884.1898	2415.569
1084.737	25.1396	13727.54	6884.548	29122.11				1312.588	3576.635
785.5809	9.147158	21126.19	8349.753	27758.91				2607.202	5454.636
588.911	6.972237	26891.01	8692.266	24164.74				5302.921	7074.238
571.7749	4.882377	30061.93	8488.715	18862.07				11931.13	8662.597
689.0964	2.156668	29892.49	7339.472	14644.86				19110.82	9110.517
701.5105	2.24679	36065.02	7491.048	13755.99				19605.88	9641.607
2767.954	1169.036	4.572004	103.8741	14632.81				2.06E-06	310.3908
2756.29	970.6148	33.72603	341.3472	15088.04				0.000467	450.9987
2934.539	971.9464	441.6745	1212.521	18959.58				3.637269	660.8523
2999.972	695.5865	1255.332	2318.242	25216.47				252.4657	1470.111
2177.351	293.0182	4075.835	4432.16	32381.58				894.3471	2477.306
947.3177	34.49674	10943.8	7348.7	35513.36				1043.107	3562.003
619.5147	13.21136	19221.92	8390.584	35455.67				1582.929	5439.097
376.1914	8.4563	27837.25	9291.283	31213.8				2616.383	8153.651
236.2891	5.973506	33034.18	10124.69	23939.9				5817.84	11501.96
278.8533	2.585592	32753.65	9478.941	16058.9				13224.83	13329.9
335	1.4967	34154.81	8483.827	12337.23				18480.53	13262.38
2767.954	1169.036	4.572004	103.8741	14632.81				2.06E-06	310.3908
2756.29	970.6148	33.72603	341.3472	15088.04				0.000467	450.9987
2935.636	966.6882	441.0525	1211.584	18852.5				3.638303	731.9533
2991.8	699.9401	1190.635	2230.372	25716.46				248.912	1743.307
2134.499	263.1485	3408.364	4149.557	34343.5				927.5407	2966.112
882.8207	35.22019	8744.843	6938.647	38281.28				1140.24	3896.643

528.5068	9.361046	15052.04	8158.573	39255.53					1565.575	5416.825
264.2906	8.562074	24693.96	8656.121	36450.33					2383.835	8032.827
95.19405	5.825642	32457.38	9828.113	31419.8					3418.25	11723.35
122.8914	3.758593	35465.61	10557.82	24951.27					4629.901	14361.42
135.8148	1.769752	36075.82	10104.71	19391.44					6148.672	15484.48
2767.954	1169.036	4.572004	103.8741	14632.81					2.06E-06	310.3908
2756.29	970.6148	33.72603	341.3472	15088.04					0.000467	450.9987
2936.33	971.3585	440.7903	1211.108	18869.04					3.639259	737.9254
2991.614	694.1699	1174.396	2203.281	25602.83					248.4919	1766.173
2125.479	230.7258	3268.148	4079.149	34794					941.7019	2993.77
869.3021	36.25816	8196.23	6782.169	39286.62					1167.757	3833.785
509.669	8.291322	13762.04	7916.809	40852.12					1613.034	5218.332
236.7996	7.553277	21682.33	8358.948	39416.23					2505.83	7825.962
57.27229	5.171442	30379.08	9201.48	36026.22					3717.738	11259.95
51.59282	3.202655	34647.04	9291.638	31649.91					5143.251	13399.21
35.60531	1.421025	34914.69	8941.338	27420.28					6476.389	14066.17
2723.613	1112.223	4.16667	106.389	24290.02	3730.559	3.73E+12	41.6667	0	258.8891	
2712.224	679.7228	68.88894	460.2781	26177.24	3680.003	3.68E+12	52.77782	55.00004	666.6672	
3394.169	310.8336	440.0004	1856.668	29605.3	4021.67	4.02E+12	78.61117	0	950.0008	
5209.726	166.9446	2176.946	6559.172	32829.75	6281.394	6.28E+12	143.889	1363.89	1109.723	
8635.562	73.88895	4585.281	13941.96	32368.36	7428.061	7.43E+12	263.0558	5577.227	2838.058	
15917.51	26.38891	8818.896	19836.68	28032.52	7192.784	7.19E+12	443.3337	11352.51	4503.892	
26571.41	6.94445	13593.07	25383.35	20881.41	5898.616	5.9E+12	713.8895	15963.35	8450.84	
32352.53	0	20179.46	32781.97	13001.4	5545.838	5.55E+12	855.0007	17786.96	14830.57	
33363.36	0	25323.63	41065.03	8964.174	6122.783	6.12E+12	1031.667	17972.24	18624.74	
29788.63	0	32780.03	49257.54	6489.172	6783.617	6.78E+12	1171.39	16933.35	21087.24	
21306.13	0	44380.04	59210.33	6169.727	7362.784	7.36E+12	1358.89	16669.74	21825.85	
2723.336	1111.668	4.16667	107.5001	24287.24	3732.225	3.73E+12	41.6667	0	258.8891	
2711.947	679.7228	68.88894	461.3893	26284.19	3680.003	3.68E+12	52.77782	60.5556	645.0005	
3444.169	311.3891	440.0004	1853.057	29655.02	4247.226	4.25E+12	78.61117	0	995.0008	
4888.337	169.7224	640.2783	4671.393	35362.53	6058.338	6.06E+12	99.44452	464.4448	836.9451	
7020.283	75.27784	1456.946	7874.729	42116.7	7136.395	7.14E+12	57.77782	2118.613	2005.002	
11575.56	26.11113	3510.836	11325.01	45774.48	8505.84	8.51E+12	69.4445	6535.283	3464.725	
18166.4	6.666672	6378.338	15277.79	45951.7	9736.674	9.74E+12	102.7779	14044.18	5545.56	
25545.58	0	11267.51	20407.79	39771.7	8978.618	8.98E+12	150.5557	24048.35	9530.285	
29928.64	0	16898.9	29787.8	31921.14	9186.118	9.19E+12	269.1669	27235.58	13415.84	
31823.08	0	24593.63	42954.76	22714.74	8708.618	8.71E+12	421.9448	26946.13	16648.07	
29988.91	0	36395.58	58303.94	15219.73	8909.452	8.91E+12	637.5005	26440.58	18721.68	
2723.336	1111.668	4.16667	107.5001	24287.24	3732.225	3.73E+12	41.6667	0	258.8891	
2711.947	679.7228	68.88894	461.3893	26284.19	3679.725	3.68E+12	52.77782	60.5556	645.0005	
3446.669	311.6669	440.0004	1842.224	29907.52	4116.948	4.12E+12	78.61117	0	993.8897	
3524.169	171.389	515.8337	3685.003	36396.14	5474.727	5.47E+12	97.50008	128.6112	471.3893	
4126.392	76.11117	898.0563	6665.005	44886.42	6021.671	6.02E+12	29.72225	866.9451	642.7783	
6314.449	26.66669	2015.279	10070.84	52916.71	6258.894	6.26E+12	29.72225	2785.836	1524.723	
11500.29	6.94445	4293.337	13736.96	56502.27	6660.283	6.66E+12	33.61114	6789.45	3208.058	
20382.79	0	6919.172	16833.35	54315.88	8646.396	8.65E+12	35.83336	14516.96	6368.338	
27893.36	0	9959.175	20825.57	54305.04	11795.29	1.18E+13	56.66671	24464.74	9375.008	

32636.41	0	15871.12	29874.47	46031.15	12613.62	1.26E+13	86.94451	31277.53	11865.57
35974.75	0	22152.8	42077.26	38055.59	12658.34	1.27E+13	128.0557	34545.86	14967.23
2723.336	1111.668	4.16667	107.5001	24287.24	3732.225	3.73E+12	41.6667	0	258.8891
2712.224	679.7228	68.88894	461.3893	26284.47	3679.725	3.68E+12	52.77782	60.5556	645.0005
3448.336	311.9447	440.0004	1665.557	29965.86	4040.003	4.04E+12	78.61117	0	975.2786
3311.392	171.6668	467.5004	3625.558	36450.31	5356.949	5.36E+12	97.50008	35.55558	431.667
3148.336	76.94451	635.0005	6074.449	45105.59	5099.171	5.1E+12	29.72225	506.6671	287.5002
4546.67	26.94447	1177.223	8940.285	53838.65	5053.615	5.05E+12	29.72225	1302.501	798.6118
7256.117	6.94445	2323.335	13221.12	61069.77	5765.838	5.77E+12	29.72225	3158.891	1445.001
13436.4	0	4750.559	16448.9	63741.72	7648.617	7.65E+12	20.00002	7042.506	2588.891
23190.3	0	7080.839	18918.63	65629.5	9550.008	9.55E+12	24.72224	14348.07	5105.282
35133.08	0	11529.18	21806.13	57218.1	11612.51	1.16E+13	24.72224	25247.24	7852.229
41283.92	0	15449.46	28912.52	50285.04	13869.73	1.39E+13	35.00003	39006.98	10218.34
2723.336	1111.668	4.16667	107.5001	24287.24	3732.225	3.73E+12	41.6667	0	258.8891
2712.224	679.7228	68.88894	461.3893	26284.47	3679.725	3.68E+12	52.77782	60.5556	645.0005
3435.558	311.9447	440.0004	1630.279	29763.63	3998.892	4E+12	78.61117	0	985.2786
3080.836	172.5001	453.6115	3245.28	36388.36	4752.504	4.75E+12	97.50008	0	448.0559
2114.168	77.50006	473.0559	5197.226	44580.31	4118.892	4.12E+12	29.72225	174.4446	260.278
1727.779	27.22224	550.8338	7971.951	53845.6	3723.336	3.72E+12	29.72225	685.5561	634.445
2930.558	6.94445	1178.89	11746.4	62267.55	3874.448	3.87E+12	29.16669	1105.279	988.3341
5298.893	0	2595.835	15788.9	68841.44	5587.782	5.59E+12	8.888896	1906.113	1200.557
10364.45	0	4669.448	19493.35	69853.67	7883.062	7.88E+12	12.77779	3392.78	1195.834
15652.79	0	7532.784	22352.24	66751.16	11211.95	1.12E+13	13.05557	7195.284	1281.112
24982.24	0	10192.51	23448.35	59086.44	12453.07	1.25E+13	13.8889	10916.12	948.6119
2723.336	1111.668	4.16667	107.5001	24287.24	3732.225	3.73E+12	41.6667	0	258.8891
2712.224	679.7228	68.88894	461.3893	26285.85	3679.725	3.68E+12	52.77782	60.5556	645.0005
3266.947	311.1114	440.0004	1528.89	30271.14	3774.17	3.77E+12	78.61117	0	948.8896
3041.947	173.3335	447.7781	2849.447	36527.25	4190.003	4.19E+12	97.50008	0	466.3893
1985.279	78.05562	405.2781	4630.281	43617.53	3564.725	3.56E+12	29.72225	175.5557	245.278
1186.112	27.22224	285.8336	6837.505	52493.1	3294.725	3.29E+12	29.72225	688.6117	660.0005
1556.39	7.222228	687.2228	9982.23	60643.1	3370.28	3.37E+12	29.72225	1023.056	924.4452
2711.669	0	1603.612	13579.46	65351.44	3961.67	3.96E+12	9.166674	1683.335	873.334
4771.67	0	2383.613	15629.73	65857.83	5550.282	5.55E+12	9.166674	3871.114	1120.279
8216.118	0	3725.281	18958.07	63204.5	8949.729	8.95E+12	9.166674	8113.34	1696.39
12345.84	0	5963.616	23475.02	63530.61	10585.56	1.06E+13	2.77778	9883.063	1734.168
2737.724	1158.751	2.833336	102.139	15226.87	3688.364	3.69E+12	3.555558		0
2805.613	1306.557	26.00002	125.139	16397.68	4098.614	4.1E+12	3.500003		94.25008
3514.419	1615.39	58.66671	307.7502	21070.74	4981.365	4.98E+12	3.888892		280.0002
5234.199	1730.501	295.4725	1256.084	25359.05	5745.06	5.75E+12	4.472226		700.5561
5958.949	2005.446	1293.557	3202.503	21784.02	5029.004	5.03E+12	4.833337		1536.057
5074.976	1914.724	2695.391	4839.754	21866.32	4658.198	4.66E+12	5.083337		2501.974
4059.587	1798.029	4021.864	7187.422	21493.43	4620.254	4.62E+12	5.30556		3815.947
3885.198	1632.307	5805.755	10967.65	18478.26	3925.67	3.93E+12	5.527782		5673.81
3898.059	1503.335	8530.868	15267.26	15660.79	3445.753	3.45E+12	5.722227		7449.867
3840.614	1295.64	11724.87	20629.1	13221.98	3006.919	3.01E+12	5.833338		9015.424
3692.947	1083.945	15502.9	26159.83	11369.7	2606.697	2.61E+12	5.944449		10256.95
2737.724	1158.751	2.833336	102.139	15226.87	3688.364	3.69E+12	3.555558		0

2805.613	1306.557	26.00002	125.139	16397.68	4098.614	4.1E+12	3.500003	94.25008
3514.419	1615.39	58.66671	307.7502	21070.74	4981.365	4.98E+12	3.888892	280.0002
5224.476	1745.251	223.9446	901.4174	26090.3	5734.671	5.73E+12	4.388892	594.556
5837.699	2055.363	734.5006	1900.113	27198.47	5593.282	5.59E+12	4.694448	1100.112
5422.865	1807.363	1635.668	3047.502	29077.3	4884.476	4.88E+12	4.916671	1763.251
4886.004	1489.946	2795.724	5001.226	27945.61	4387.031	4.39E+12	5.138893	2837.058
4233.142	1508.168	3711.781	6769.117	28782.72	4339.281	4.34E+12	5.388893	3930.086
3848.17	1526.723	4841.782	9145.98	28519.55	4246.003	4.25E+12	5.583338	5175.421
3630.92	1526.112	6627.644	12537.45	26805.1	4063.059	4.06E+12	5.694449	6780.922
3672.892	1479.112	9305.813	17063.1	23532.49	3762.059	3.76E+12	5.777782	8480.812
2737.724	1158.751	2.833336	102.139	15226.87	3688.364	3.69E+12	3.555558	0
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3514.419	1615.39	58.66671	307.7502	21070.74	4981.365	4.98E+12	3.888892	280.0002
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5521.671	2018.307	619.2505	1630.029	28848.47	5914.588	5.91E+12	4.694448	1011.529
4668.17	1949.696	1255.807	2375.53	31975.78	5551.643	5.55E+12	4.888893	1563.279
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3233.725	1581.973	2421.446	4383.726	39342.64	4439.781	4.44E+12	5.333338	2960.752
2942.197	1435.973	3278.308	5957.449	41228.87	4150.198	4.15E+12	5.527782	3686.281
2523.585	1384.779	4154.809	7680.867	43310.7	4113.503	4.11E+12	5.638893	4375.726
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3216.669	1617.835	42.50003	165.2501	21146.71	5103.504	5.1E+12	4.222226	272.278
3633.781	1917.557	72.63895	217.5002	26316.05	6194.366	6.19E+12	4.805559	572.6671
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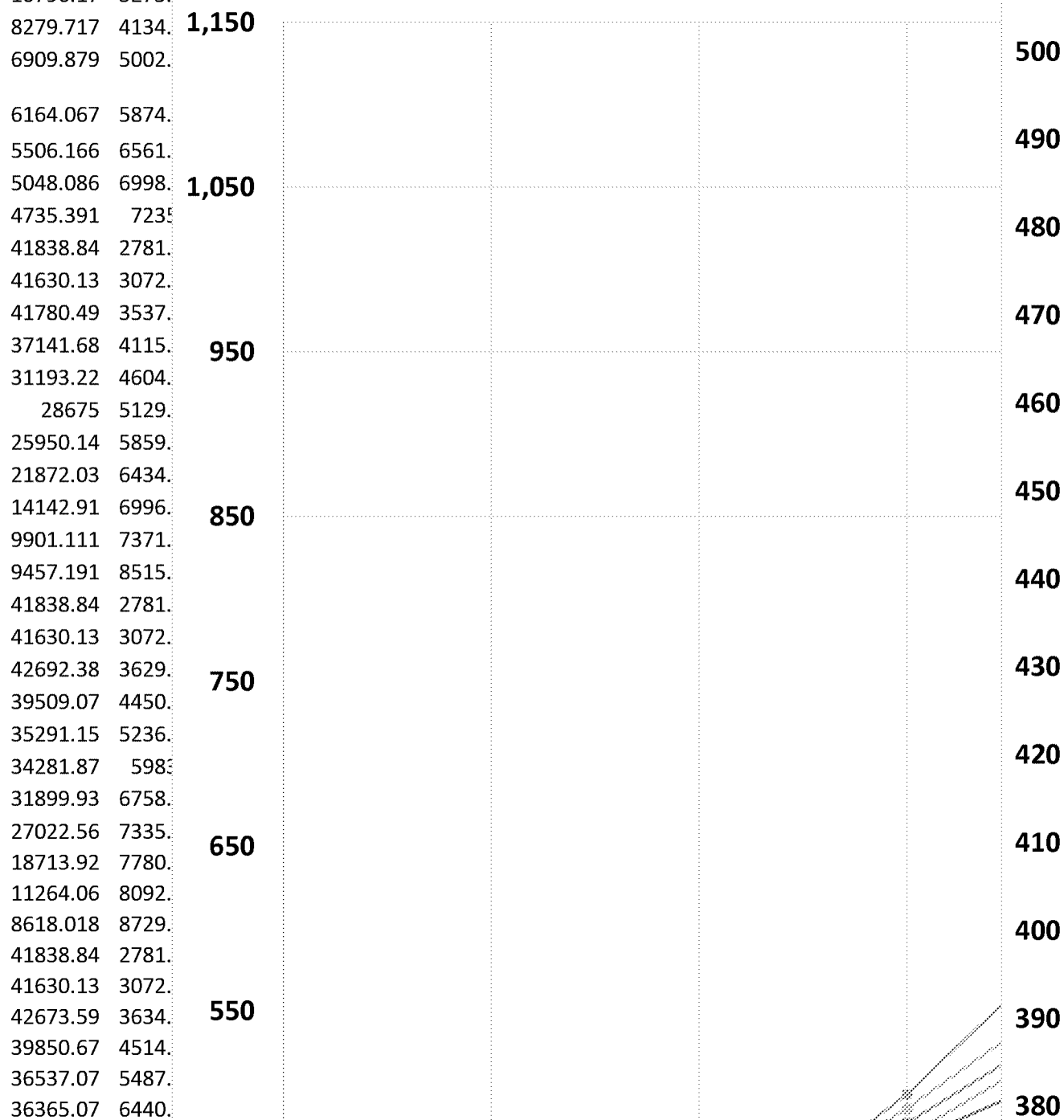
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2811.113	1126.112	1.722224	106.9445	15644.46	3627.781	3.63E+12	0	96.36119	0
2830.558	1113.334	65.72227	483.8893	17208.35	3411.114	3.41E+12	0.027778	108.889	60.33338
3377.78	803.334	458.6115	1328.334	22319.46	3366.669	3.37E+12	0.027778	132.5557	1175.834
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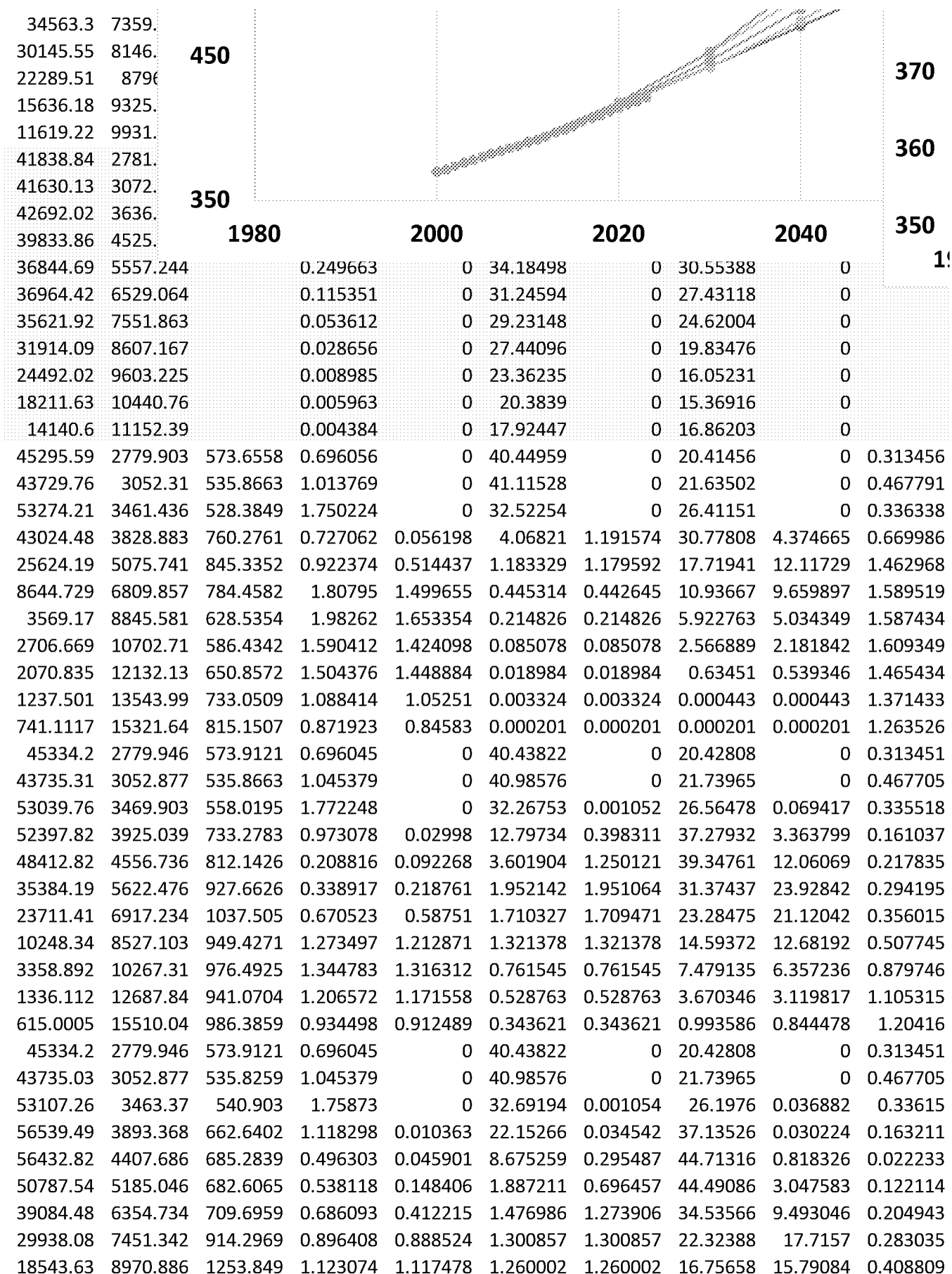
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3377.78	803.334	458.6115	1328.334	22319.46	3366.669	3.37E+12	0.027778	132.5557	1175.834
4775.004	383.0559	515.2782	2257.78	20388.91	3208.336	3.21E+12	6.472227	213.9724	1205.557
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13272.23	0.027778	6366.672	8797.229	18636.13	3038.891	3.04E+12	1037.779	2571.669	16463.9
17527.79	0.027778	18850.02	13844.46	16175.01	4652.782	4.65E+12	3486.114	4313.892	31250.03
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21152.79	0.027778	59833.38	24741.69	12777.79	10963.9	1.1E+13	10680.56	9902.786	38055.59
19611.13	0.027778	81166.73	30722.25	5277.782	13616.68	1.36E+13	13561.12	13519.46	36833.36
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3377.78	803.334	458.6115	1328.334	22319.46	3366.669	3.37E+12	0.027778	132.5557	1175.834
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2830.558	1113.334	65.72227	483.8893	17208.35	3411.114	3.41E+12	0.027778	108.889	60.33338
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2684.724	0.027778	3691.67	9486.119	76333.39	5975.005	5.98E+12	232.8891	1901.668	3705.559
5347.227	0.027778	11136.12	13575.01	76944.51	6025.005	6.03E+12	815.0007	2174.446	4325.003
9141.674	0.027778	22469.46	17286.12	83333.4	6394.45	6.39E+12	1565.279	2550.835	5058.337

Secondary electricity (oil)	Secondary electricity per capita	Secondary heat per capita	Secondary electricity (% biomass)	Secondary electricity (% biomass CCS)	Secondary electricity (% coal)	Secondary electricity (% coal CCS)	Secondary electricity (% gas)	Secondary electricity (% gas CCS)	Secondary electricity (% geothermal)
41838.84	2781.358		1.215466	0	39.90404	0	20.14455	0	
41630.13	3072.679		1.586964	0	40.42689	0	22.19814	0	
38125.11	3187.006		2.445846	0.007004	21.72262	0.008205	25.0612	0.26517	

SSP Baseline Scenario CO2 Co





9023.341	11060.15	1363.053	1.168648	1.154806	0.945286	0.945286	11.00011	9.968518	0.595451
4483.059	13384.33	1401.434	1.112786	1.095093	0.85705	0.85705	5.662502	4.813035	0.916331
45334.2	2779.946	573.9121	0.696045	0	40.43822	0	20.42808	0	0.313451
43735.03	3052.917	535.8259	1.045365	0	40.98521	0	21.73936	0	0.467698
53093.93	3457.421	530.7937	1.759645	0	32.82525	0	26.65963	0	0.336729
56576.43	3908.599	648.3848	1.032223	0.003441	23.16479	0.012903	37.64344	0	0.155694
58408.94	4399.783	580.3006	0.340564	0.01437	12.22509	0.056761	46.58538	0	0.016525
56748.66	5125.335	551.1566	0.174961	0.049651	6.824052	0.145406	48.43393	0	0.013595
48098.65	6248.592	614.387	0.228793	0.124107	4.470697	0.278057	44.30813	0.135949	0.006632
36943.09	7385.928	808.7887	0.326106	0.279179	2.192068	0.449788	35.99216	0.900768	0.00517
27800.58	8525.839	1015.174	0.561064	0.558986	0.657692	0.657692	25.48825	4.440719	0.027361
18739.18	10047.94	1254.871	0.759696	0.758501	0.905183	0.905183	12.89871	9.553413	0.168788
12387.51	12111.9	1535.55	0.854664	0.853648	1.168752	1.168752	9.367787	8.762972	0.314088
45334.2	2779.946	573.9121	0.696045	0	40.43822	0	20.42808	0	0.313451
43735.03	3052.877	535.8259	1.045379	0	40.98576	0	21.73965	0	0.467705
53162.82	3457.421	525.3923	1.793424	0	32.90653	0	26.9668	0	0.337784
57157.55	3936.74	575.2251	1.021428	0	25.35037	0	37.84919	0	0.140062
59353.66	4437.907	468.742	0.512156	0	18.49032	0	46.17806	0	0.008548
59348.94	5151.995	406.0739	0.797361	0	15.53972	0	48.96361	0	0.007056
53158.1	6273.396	412.8472	0.696404	0	14.59664	0.008965	46.69255	0	0.003303
47861.43	7518.636	590.8695	0.673126	0	12.53311	0.047662	43.40313	0	0.001563
52468.38	8662.938	837.9764	1.105051	0.000341	8.288568	0.142477	38.46104	0	0.001363
58356.99	9956.237	1211.586	1.262045	0.004221	4.785881	0.323802	34.1156	0	0.001206
61899.22	11504.25	1378.708	1.542183	0.01497	1.28395	0.463805	28.49284	0	0.000802
45334.2	2779.86	573.9121	0.696066	0	40.43946	0	20.42717	0	0.31346
43735.59	3052.877	535.8259	1.045379	0	40.98708	0	21.73832	0	0.467705
52792.26	3459.064	495.8673	1.792572	0	33.71703	0	26.96455	0	0.337624
57207.55	3960.913	507.1421	1.033019	0	27.41533	0	37.16917	0	0.134963
60081.99	4441.194	405.6762	0.590073	0	23.18654	0	44.35729	0	0
60399.49	5157.629	359.3288	0.951559	0	21.75486	0	47.66604	0	0
54948.38	6276.06	359.125	0.734309	0	22.41412	0	45.86674	0	0
50013.1	7597.561	418.9193	0.71098	0	22.39646	0	42.58149	0	0
55763.66	8758.638	589.9999	1.10208	0	23.29606	0	38.24139	0	0
64661.72	10069.07	967.1253	1.311102	0	21.04143	0	34.01114	0	0
71455.89	11668.81	1171.952	1.514373	0	16.50419	0	32.37875	0	0
42995.26	2783.926	568.2285	2.087359	0	38.88077	0	20.51158	0	0.298524
46243.04	2946.698	595.7644	1.859977	0	40.41661	0	19.99838	0	0.278024
56340.13	3261.041	647.1109	1.678197	0	39.92053	0	19.20377	0	0.265794
61105.08	3488.833	674.7537	1.800297	0	33.0187	0	18.52337	0	0.259216
58086.77	3568.272	543.2521	7.063804	1.367435	17.28773	4.156208	16.10556	3.896865	0.26834
55675.96	3944.806	467.8253	15.70704	8.918907	14.99667	9.63006	12.78888	8.188942	0.250912
51254.32	4337.541	436.9298	19.90442	15.92041	14.82666	12.60271	10.72559	9.116758	0.23389
43728.53	4924.507	353.1112	25.17596	20.53821	10.03637	8.530924	8.194734	6.965506	0.211476
36925.67	5459.901	296.1944	26.47527	21.751	7.063829	6.004274	6.36918	5.41384	0.195135
30847.27	6002.84	247.8027	26.6202	21.96623	4.93995	4.198946	4.646615	3.949619	0.181294
26235.8	6529.61	206.5506	25.87955	21.41041	3.46074	2.941621	3.39976	2.88981	0.170905
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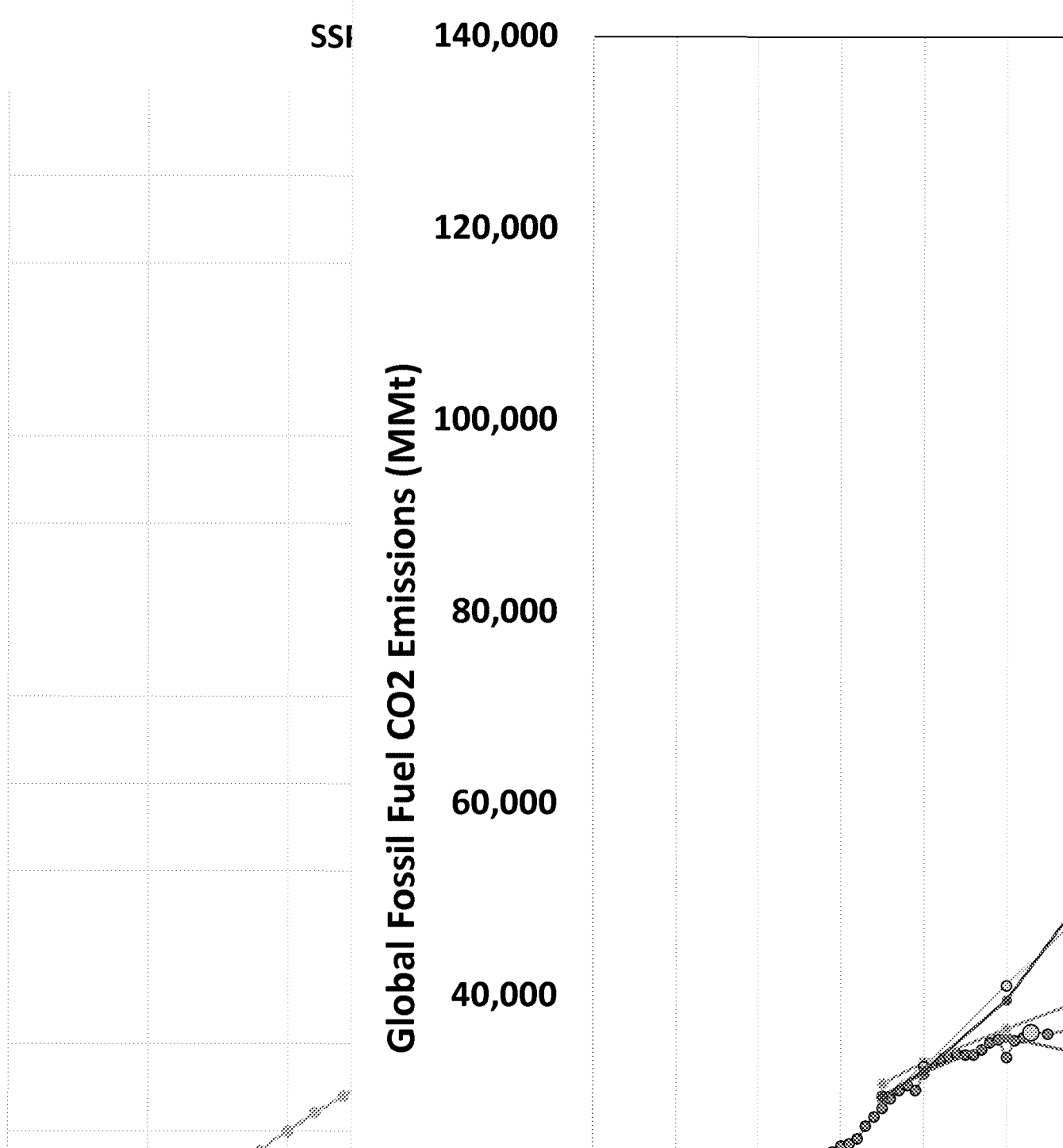
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56340.13	3261.041	647.1109	1.678197	0	39.92053	0	19.20377	0	0.265794
63034.22	3567.87	673.5335	1.613197	0	36.92238	0	17.24105	0	0.249359
64468.88	3531.7	604.2075	4.182849	0	26.6148	2.049665	16.48865	0	0.261348
62483.47	3621.182	490.5506	12.26769	1.029247	20.86637	9.652352	13.14286	3.548592	0.26386
56033.54	4038.857	414.8743	21.35897	9.818478	17.21295	14.38512	9.563974	6.407874	0.243057
53688.07	4213.208	390.3152	22.68834	18.37713	15.99039	13.59184	8.847122	7.520021	0.239706
49942.43	4520.982	364.9834	24.34278	19.86945	14.60162	12.41138	7.834006	6.658871	0.229059
45456.29	4926.94	334.8401	25.38766	20.85011	12.44142	10.5752	6.683619	5.681093	0.215123
40027.73	5450.881	298.0997	26.25617	21.67921	9.463636	8.044074	5.403823	4.593274	0.199801
42995.26	2783.926	568.2285	2.087359	0	38.88077	0	20.51158	0	0.298524
46243.04	2946.698	595.7644	1.859977	0	40.41661	0	19.99838	0	0.278024
56340.13	3261.041	647.1109	1.678197	0	39.92053	0	19.20377	0	0.265794
63160.05	3578.926	673.3997	1.593537	0	37.29765	0	17.11258	0	0.247495
65919.14	3629.62	638.9162	3.665904	0	32.35244	0.013062	16.07689	0	0.249503
65062.61	3700.082	557.5545	9.920773	0	28.94826	1.371164	14.20127	0	0.251523
62316.36	3789.241	481.3113	15.86175	0	27.98383	2.247802	11.99188	0	0.252413
59921.66	3864.099	399.3551	22.07603	0	22.84492	7.415924	9.931071	0.496537	0.25509
57223.05	4016.51	356.748	24.57677	1.176429	20.86058	13.49151	8.032102	2.608962	0.252003
55341.52	4261.305	338.9972	25.40165	4.732448	21.28436	18.0917	6.780486	3.27007	0.243622
52840.65	4600.414	322.8397	26.90623	8.610958	21.11454	17.94734	5.695377	3.861334	0.23224
42995.26	2783.926	568.2285	2.087359		38.88077		20.51158		0.298524
46344.01	2944.622	597.3916	1.861288		40.76171		20.03593		0.278357
57190.52	3312.546	662.9775	1.64437		43.49415		18.84483		0.263731
64383.13	3694.294	727.5244	1.508624		46.64222		18.33072		0.248597
67908.67	3996.211	766.4564	1.595163		49.67945		17.44903		0.240956
67077.58	4333.171	769.1953	2.030835		52.49602		16.56388		0.22984
64340.94	4531.551	733.654	2.637827		55.37246		15.20623		0.225848
62541.61	4733.012	705.8475	3.409174		58.62282		13.36947		0.222513
60682.22	4942.87	682.1853	4.039637		61.38022		11.69091		0.218638
59865.8	5160.394	658.0579	4.319854		63.88211		10.28177		0.214618
57837.8	5408.951	639.5627	4.70986		66.11424		9.031997		0.210668
46067.12	3157.644		1.006834	0	40.65061	0	23.42063	0	0.312704
49843.43	4003.837		1.267989	0.052744	39.62068	0.227985	24.33558	0.483954	1.538498
47262.85	5200.497		3.268448	2.308036	20.37439	9.647666	19.8147	5.745056	2.7188
44584.21	6295.292		4.470614	4.197032	13.7283	12.39756	15.87799	9.184309	2.592186
39981.31	7351.069		5.654321	5.623829	11.18139	11.08924	12.69454	10.80232	2.328764
30816.31	8279.944		6.576603	6.574768	8.410661	8.404808	11.06671	10.85472	2.088213
22251.64	9109.956		7.254412	7.254341	5.105977	5.105861	9.00403	8.980599	1.90018
14228.09	9828.18		8.001509	8.001507	1.760085	1.760084	6.050449	6.032606	1.744063
8034.094	10531.78		9.37287	9.37287	0.358106	0.358106	3.25817	3.242208	1.628544
3690.22	11456.25		14.51441	14.51441	0.056408	0.056408	0.987427	0.978228	1.189065
46067.12	3157.644		1.006835	0	40.65061	0	23.42063	0	0.312704
49843.43	4003.837		1.267989	0.052744	39.62068	0.227986	24.33558	0.483954	1.538498
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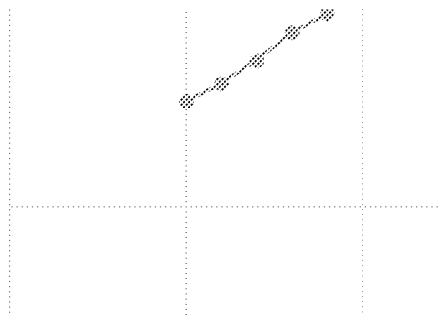
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47189.81	6550.439		3.535409	3.033918	11.83977	9.541207	15.35014	7.223306	2.431648
41231.65	7384.546		4.451707	4.355914	9.326567	9.106902	11.49764	8.863253	2.233892
34958.58	8295.921		5.488764	5.480709	7.177804	7.167891	9.148849	8.741092	1.987339
26399.93	9113.482		6.314989	6.314709	5.147211	5.146998	7.629604	7.585801	1.76257
17545.93	9823.1		7.024394	7.024387	2.29436	2.294356	5.488303	5.468959	1.600282
11332.19	10534.38		8.251259	8.251259	0.532057	0.532057	3.182813	3.167756	1.428865
46067.12	3157.644		1.006835	0	40.65061	0	23.42063	0	0.312704
49843.43	4003.837		1.267989	0.052744	39.62068	0.227986	24.33558	0.483954	1.538498
50641.89	4709.373		1.734062	0.221519	33.75131	1.504065	22.85241	1.765053	2.311854
50713.45	5435.012		2.151612	0.578059	25.82325	3.416516	20.42134	3.096103	2.429575
50029.78	6128.109		2.603507	1.408735	16.67887	6.103642	17.6895	4.645674	2.385478
46474.04	6813.908		3.162545	2.607327	10.26992	7.642782	13.29249	6.436765	2.308694
42901.34	7638.936		4.02599	3.902503	7.574021	7.344423	9.648538	7.289695	2.104043
42506.8	7942.938		4.20342	4.134149	6.421084	6.324107	8.407934	7.106921	1.849905
42125.74	8282.231		4.408569	4.374713	5.738493	5.706966	7.276329	6.661463	1.635354
38890.24	8781.601		4.810067	4.803094	4.57199	4.567466	5.97997	5.785993	1.476014
46067.12	3157.644		1.006835	0	40.65061	0	23.42063	0	0.312704
49843.43	4003.837		1.267989	0.052744	39.62068	0.227986	24.33558	0.483954	1.538498
50826.34	4689.391		1.544299	0.085761	36.94194	0.515173	23.86642	1.069824	2.09357
51518.91	5248.011		1.799303	0.127814	32.87464	0.760354	22.54129	1.500502	2.153448
52308.74	5667.525		1.988386	0.175098	29.33605	0.98898	21.25647	1.805718	2.040826
51682.61	5986.998		2.130593	0.227158	26.904	1.142903	17.41396	2.112599	1.96217
53753.55	6344.514		2.202876	0.292322	24.51118	1.293878	14.09185	2.058233	1.878826
55059.47	6715.803		2.157285	0.435159	17.54567	1.643276	12.10213	2.223358	1.89223
54660.59	7169.149		2.016188	0.685798	10.76994	2.087704	10.16558	2.533821	1.816117
52197.79	7709.467		1.864113	1.143814	4.908091	2.584298	8.315845	3.079259	1.665156
44438.52	2863.073		0.76537	0	40.1786	0	21.58359	0	0.312421
46067.12	3157.644		1.006835	0	40.65061	0	23.42063	0	0.312704
50222.33	4038.961		1.195639	0	40.53361	0	24.9766	0	1.471647
49623.75	4730.289		1.48725	0	37.90482	0	24.30973	0	2.014797
49454.3	5280.881		1.70203	0	34.18735	0	23.25021	0	2.066883
49764.59	5688.799		1.849673	0	31.07542	0	22.22932	0	1.946633
48562.2	5963.946		1.977236	0	29.20874	0	18.79074	0	1.85916
50766.15	6253.691		2.086927	0	27.79992	0	15.5909	0	1.746555
52918.32	6499.741		2.10228	0	22.33832	0	14.14748	0	1.727686
54199.26	6744.752		2.019211	0	18.58211	0	12.92109	0	1.648129
54754.16	6984.24		1.826926	0	15.69381	0	12.53351	0	1.529551
39472.25	2828.169	557.6911	0.523932	0	40.32916	0	20.68549	0	0.331119
40500.03	3122.283	494.7946	0.647955	0	39.51478	0	23.93857	0	0.422893
57583.38	3865.793	445.7984	0.630447	0.000285	29.07707	0.000761	39.20076	0.000285	0.386394
79750.06	4128.387	303.6796	1.475355	0.923977	12.79866	0.000919	43.43358	0.829407	0.788638
62805.61	5302.343	264.1916	6.938903	6.627182	1.970698	0.000748	19.93766	3.648379	0.756858
29277.8	8143.276	507.7001	9.04175	8.942346	0.005646	0.000398	6.687873	2.845726	0.487475
7402.784	11293.52	881.6193	7.766323	7.743414	0.001632	0.000258	2.845934	2.07732	0.343643

3405.558	14284.69	1235.007	6.911934	6.907335	0.000368	0.000184	1.405151	1.156818	0.262819
2757.502	17296.76	1449.866	6.425774	6.421857	0.000392	0.000157	0.439287	0.345672	0.219546
2395.557	20669.29	1558.976	5.742234	5.740518	0.00036	0.000137	0.181569	0.122344	0.191351
2192.502	24079.12	1691.527	5.240106	5.238542	0.000297	0.000125	0.054075	0.012639	0.175192
39472.25	2828.169	557.6911	0.523932	0	40.32916	0	20.68549	0	0.331119
40500.03	3122.283	494.7946	0.647955	0	39.51478	0	23.93857	0	0.422893
57583.38	3865.793	445.7984	0.630447	0.000285	29.07707	0.000761	39.20076	0.000285	0.386394
83333.4	4659.524	398.3531	0.849001	0.139748	12.28719	0.003257	56.69134	1.572909	0.598816
86694.51	5649.442	379.4944	2.130486	1.239906	2.568754	0.009128	54.49971	13.34699	0.644822
69027.83	7430.942	354.2244	4.396514	3.807407	0.022266	0.00841	37.29847	20.11329	0.522876
38361.14	9919.026	541.714	5.712423	5.360287	0.008445	0.005739	22.31497	16.52755	0.401695
17077.79	12934.73	930.1966	5.241239	5.050787	0.003606	0.003428	13.08278	11.00305	0.309294
6988.894	16114.51	1337.061	4.969519	4.881228	0.001535	0.001282	5.427791	4.914862	0.25247
2794.447	19853.45	1738.817	5.204574	5.079507	0.000447	0.000214	1.947472	1.762194	0.208505
2283.613	23401.15	2030.133	5.35812	5.163367	0.000306	0.000129	0.904877	0.814582	0.184291
39472.25	2828.169	557.6911	0.523932	0	40.32916	0	20.68549	0	0.331119
40500.03	3122.283	494.7946	0.647955	0	39.51478	0	23.93857	0	0.422893
57583.38	3865.793	445.7984	0.630447	0.000285	29.07707	0.000761	39.20076	0.000285	0.386394
79222.29	4880.257	462.5035	0.667138	0.050459	13.75265	0.067774	59.27208	1.087633	0.542544
86916.74	5933.732	447.2613	1.109192	0.396992	4.304178	0.326797	65.68245	10.71309	0.57493
83388.96	7524.841	417.0394	1.774096	1.148881	1.057229	0.422935	58.21859	28.61876	0.490964
66000.05	9511.528	414.9367	2.841891	2.422305	0.346821	0.327134	43.55661	29.33356	0.408024
40583.37	11840.96	635.5687	3.564494	3.306519	0.222746	0.222497	27.35368	22.14424	0.341748
22422.24	14972.91	1009.825	3.91629	3.803167	0.107059	0.10681	13.86199	12.14932	0.278733
12330.57	18509.07	1527.407	4.518973	4.495975	0.033768	0.033538	5.239555	4.718283	0.233231
8663.896	22128.08	2048.213	4.737021	4.733617	0.026774	0.026604	2.765957	2.561702	0.209702
39472.25	2828.169	557.6911	0.523932	0	40.32916	0	20.68549	0	0.331119
40500.03	3122.283	494.7946	0.647955	0	39.51478	0	23.93857	0	0.422893
57583.38	3865.793	445.7984	0.630447	0.000285	29.07707	0.000761	39.20076	0.000285	0.386394
79055.62	4911.297	467.332	0.744382	0.038904	14.57163	0.148455	58.84129	0.594733	0.530056
86916.74	5980.012	507.0944	1.508015	0.304809	6.296296	0.939746	65.11885	5.440022	0.557767
85722.29	7466.559	539.1076	2.470512	0.945794	3.685603	2.112316	59.06331	17.07719	0.48569
74527.84	9178.414	507.7558	3.193094	1.911557	2.437984	2.275194	47.67442	23.61522	0.416138
55500.04	11147.91	525.8633	3.459045	2.512669	1.972599	1.971715	35.1208	21.26105	0.360047
45694.48	13675.49	653.1171	3.173148	2.625712	1.64429	1.644043	23.32425	15.69978	0.305177
39527.81	16423.34	898.1406	2.814255	2.585313	1.532181	1.531965	14.32613	10.78618	0.263067
37694.47	18881.37	1128.814	2.525434	2.415719	1.754638	1.754438	9.694794	8.188709	0.245761
39472.25	2828.169	557.6911	0.523932	0	40.32916	0	20.68549	0	0.331119
40500.03	3122.283	494.7946	0.647955	0	39.51478	0	23.93857	0	0.422893
57583.38	3865.793	445.7984	0.630447	0.000285	29.07707	0.000761	39.20076	0.000285	0.386394
79416.73	5069.949	478.0237	0.636803	0.00551	20.05442	0.03551	56.07483	0.016871	0.473673
88750.07	6320.499	551.7214	1.021967	0.038598	14.58159	0.298954	64.69665	0.201726	0.482374
89416.74	7680.259	643.0436	1.736088	0.123019	10.81366	1.064503	64.79764	1.077572	0.453626
82250.07	8897.046	718.2966	2.531443	0.248128	8.451472	2.300981	56.63395	3.571792	0.420574
70472.28	10300.48	739.6903	2.970026	0.386161	6.001276	3.157844	43.14413	6.495536	0.384247
66666.72	12320.47	719.174	2.881496	0.519934	4.234259	3.445147	29.33737	7.748144	0.338741
59861.16	14965.46	727.1675	2.600142	0.66319	3.697559	3.621711	18.6466	6.577388	0.290353

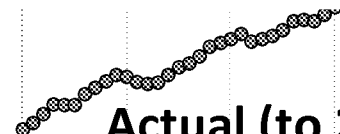
52694.49	17355.95	807.9103	2.599826	0.812934	3.422309	3.415799	11.0178	4.205729	0.267361
39472.25	2828.169	557.6911	0.523932	0	40.32916	0	20.68549	0	0.331119
40500.03	3122.283	494.7946	0.647955	0	39.51478	0	23.93857	0	0.422893
58083.38	3939.357	439.9133	0.597572	0	34.72456	0	34.64986	0	0.337255
80611.18	5114.785	479.7482	0.577141	0	35.42819	0	43.46595	0	0.338368
89944.52	6624.623	580.1504	0.852794	0	38.37824	0	47.58982	0	0.327495
91583.41	8208.034	679.9555	1.29073	0	40.8284	0	46.70611	0	0.349862
86416.74	9627.956	729.2926	1.682902	0	43.29862	0	42.69399	0	0.33994
75055.62	11036.23	733.1211	2.062798	0	43.77976	0	38.27381	0	0.325595
70250.06	12699.87	728.6591	2.3745	0	40.97093	0	33.58229	0	0.309949
61694.49	14710.07	769.3787	2.575356	0	35.51965	0	27.63443	0	0.289125
49500.04	16903.97	867.044	2.713904	0	29.25579	0	20.52139	0	0.27451

Secondary electricity (% of economy)	Secondary electricity (% renewable, excl. bio)	Secondary electricity (% nuclear)	Secondary electricity (% oil)	Secondary electricity (% solar)	Secondary electricity (% wind)	Carbon intensity of economy	Carbon intensity of energy	Primary energy intensity	Final energy intensity
16.14023	17.06101	15.23886	6.436079	0.025171	0.571875	0.577727	0.260113	2.221063	1.648901
16.17853	18.26484	12.95952	4.563633	0.158573	1.604945	0.518374	0.252548	2.052572	1.49021
18.22686	25.00145	11.81878	2.060006	2.076745	5.277188	0.326167	0.247407	1.318341	0.945668
-	-	-	-	-	22.7000578	0.115387	0.163112	0.706788	0.488868





20,000



**Actual (to 2023) & EIA-I
Global Emissions**

0

1970

1980

1990

2000

2010

2020

995

2000

2005

11.26881	39.58163	1.560793							
10.13062	45.28722	0.794722	0.0						
9.408441	52.35353	0.331511	0.0						
8.980302	60.49473	0.074853	0.0						
8.965427	64.1711	0.065795	0.004084	44.18429	11.84934	0.054524	0.138269	0.394334	0.297237
9.409294	65.16141	0.045884	0.001831	44.99419	11.52261	0.043533	0.12646	0.344239	0.25956
16.29661	17.22162	15.06584	6.152333	0.023048	0.588497	0.668059	0.292755	2.281976	1.587487
17.06179	20.05407	12.93913	3.242735	0.328647	2.195836	0.597187	0.290235	2.057602	1.48848
16.19906	25.25278	12.88313	1.17982	1.670093	7.047288	0.405673	0.256414	1.582101	1.207961
18.872	47.15805	16.46866	0.527735	6.881624	20.73444	0.167401	0.167097	1.001822	0.833941
17.48711	60.4899	19.36175	0.165666	10.28064	31.25919	0.063677	0.080966	0.786463	0.644932
13.78873	61.27099	25.49236	0.042263	14.12372	31.76902	0.016926	0.02474	0.684166	0.545096
11.32285	59.8624	32.00869	0.008365	16.3746	30.57752	-0.00562	-0.00898	0.625409	0.488935
9.85781	63.79322	31.9644	0	19.93737	32.38869	-0.02036	-0.03612	0.563533	0.438058
8.974659	68.60938	29.23275	0	22.18839	35.9809	-0.02806	-0.05487	0.511473	0.397787
8.314809	75.14068	23.76714	0	26.15385	39.30059	-0.02831	-0.06001	0.471782	0.365182
7.615479	83.73213	15.39555	0	32.06847	42.78465	-0.02586	-0.05855	0.441668	0.340332
16.29329	17.22442	15.06407	6.149166	0.023048	0.594634	0.668122	0.292758	2.282168	1.58728
17.05465	20.05167	12.93541	3.242133	0.328586	2.200729	0.596795	0.28955	2.061109	1.488676
16.15743	25.17538	13.04101	1.179044	1.666018	7.016418	0.40222	0.254985	1.577428	1.205151
16.52604	33.06665	15.07414	0.523372	1.974422	14.40515	0.242461	0.211491	1.146435	0.931109
15.03961	38.56298	17.53292	0.188004	3.638672	19.66687	0.142606	0.153132	0.93126	0.759462
14.34067	43.41267	22.45368	0.050649	6.810136	21.96766	0.071463	0.089071	0.802315	0.638521
12.51615	46.23232	27.98441	0.01027	9.825501	23.53465	0.033442	0.046263	0.72287	0.56273
11.34091	51.12865	31.67863	0	13.97264	25.30735	0.006076	0.009246	0.657133	0.499049
10.21213	59.42815	30.9861	0	17.49599	30.84029	-0.01037	-0.01751	0.592459	0.452524
8.854584	67.49068	27.10364	0	20.94633	36.58445	-0.0143	-0.02662	0.53708	0.412805
7.5202	76.32189	21.40641	0	25.97956	41.61797	-0.01593	-0.03241	0.491396	0.383413
16.29329	17.22442	15.06407	6.149166	0.023048	0.594634	0.668122	0.292758	2.282168	1.58728
17.05465	20.05167	12.93541	3.242133	0.328586	2.200729	0.596744	0.289543	2.060989	1.488551
16.10044	25.09431	13.07509	1.182322	1.669161	6.988556	0.412084	0.261177	1.577796	1.204336
14.8168	28.03948	10.95586	0.532811	1.603613	11.45586	0.294149	0.240243	1.224382	0.97014
15.33734	34.88679	10.65402	0.196513	2.31871	17.20851	0.206159	0.204076	1.010206	0.821462
13.41264	38.9566	13.28176	0.05609	4.238922	21.18293	0.141676	0.161956	0.874781	0.706071
12.57231	43.01052	19.28372	0.011644	7.199083	23.03418	0.087226	0.113476	0.768672	0.608792
11.81099	45.80158	28.92553	0	9.819102	23.88846	0.046152	0.066361	0.695468	0.544662
10.67974	47.56706	33.05235	0	11.80116	24.67735	0.020215	0.031531	0.641114	0.493336

9.68979	54.98046	31.88704	0	15.5067	29.18851	0.004044	0.006903	0.585878	0.44834
8.563373	62.60943	29.75754	0	18.32432	34.80541	-0.00267	-0.00492	0.541757	0.416058
16.29329	17.22442	15.06407	6.149166	0.023048	0.594634	0.668122	0.292758	2.282168	1.58728
17.05443	20.05141	12.93656	3.24209	0.328581	2.2007	0.596732	0.289543	2.060949	1.488522
16.12815	24.46614	13.10392	1.185412	1.672033	6.329234	0.417799	0.264165	1.581587	1.205914
14.54316	27.37368	10.25427	0.531595	1.447692	11.22714	0.310348	0.247914	1.251841	0.989502
14.86985	32.24075	8.143353	0.199021	1.642466	15.71191	0.239541	0.226552	1.057331	0.85328
12.88915	34.43176	9.674845	0.057335	2.505009	19.024	0.185556	0.199906	0.928215	0.743237
10.97258	37.48697	12.37376	0.011842	3.961953	22.54581	0.139553	0.170275	0.819579	0.6468
10.19678	40.55287	19.23667	0	6.801298	23.54962	0.101857	0.14069	0.723981	0.573164
10.2602	42.70391	28.91386	0	8.828449	23.5879	0.065133	0.09918	0.656716	0.521982
10.2441	46.26381	37.78436	0	12.39921	23.4517	0.033439	0.055434	0.603213	0.478972
9.059032	49.92345	37.73674	0	14.12201	26.42831	0.017029	0.029832	0.570838	0.443847
16.29329	17.22442	15.06407	6.149166	0.023048	0.594634	0.668121	0.292758	2.282163	1.58728
17.05333	20.05035	12.93673	3.242133	0.328586	2.200729	0.596708	0.28955	2.060813	1.488463
15.88748	24.09247	13.05536	1.185412	1.672033	6.195176	0.418759	0.264438	1.58358	1.206147
14.26412	25.77653	9.47212	0.530357	1.394642	9.97771	0.322457	0.252317	1.277982	1.001187
14.49066	29.03973	5.421442	0.198736	1.213075	13.32744	0.266532	0.242321	1.099913	0.8697
12.41143	30.46025	3.657511	0.057626	1.166052	16.87571	0.227439	0.23127	0.983437	0.764017
10.40784	32.36532	4.977683	0.011795	2.002397	19.95178	0.194991	0.22004	0.886164	0.675987
9.11474	34.97285	7.452436	0	3.650818	22.20573	0.164971	0.209359	0.787984	0.59984
8.272548	37.92351	12.71798	0	5.72977	23.91983	0.140623	0.196976	0.71391	0.552205
7.641611	40.07911	16.98906	0	8.175854	24.26044	0.120855	0.183145	0.659888	0.51582
8.834741	41.21017	24.04192	0	9.808864	22.56576	0.102945	0.16847	0.611061	0.484965
16.29226	17.22342	15.06454	6.149355	0.023049	0.594653	0.66809	0.29276	2.282045	1.587266
17.05333	20.05035	12.93673	3.242133	0.328586	2.200729	0.596703	0.289546	2.060826	1.488436
16.11943	23.93543	12.40874	1.181684	1.671239	5.807132	0.417429	0.262126	1.59248	1.2081
14.34683	24.55734	9.295476	0.529666	1.368305	8.70724	0.326607	0.252264	1.294702	1.008225
13.51474	26.41806	5.087159	0.200013	1.038501	11.86482	0.277522	0.247448	1.121538	0.877105
11.47274	26.53556	2.508121	0.057563	0.604416	14.4584	0.244927	0.242112	1.011625	0.773323
9.587523	27.70237	2.642476	0.012262	1.166783	16.94807	0.218891	0.23751	0.921606	0.687514
8.561531	29.69338	3.77411	0	2.231913	18.89993	0.195925	0.234906	0.834058	0.615122
8.009885	29.87213	5.791229	0	2.892917	18.96932	0.186033	0.239752	0.775937	0.568193
7.356839	31.70077	8.817593	0	3.997997	20.34593	0.173938	0.241092	0.72146	0.531625
6.570628	34.50166	11.71359	0	5.658209	22.27282	0.158871	0.236505	0.671744	0.501568
16.02466	16.95758	15.1503	6.412414	0.015679	0.565227	0.628085	0.276043	2.275321	1.696066
16.36955	17.4404	13.8398	6.445106	0.128255	0.617297	0.607927	0.290309	2.094075	1.547959
16.99498	18.76248	13.99999	6.435043	0.233704	1.225949	0.478823	0.281675	1.699913	1.260855
17.6898	23.21142	17.6206	5.825624	0.994689	4.228529	0.37131	0.260101	1.42756	1.075155
21.51475	35.43196	18.03978	6.071171	3.916038	9.695071	0.216502	0.19221	1.126387	0.854092
19.24449	38.71231	12.92035	4.874682	6.862177	12.3215	0.137752	0.126094	1.092455	0.800055
17.07048	41.77232	8.85083	3.920116	8.768587	15.67023	0.092873	0.086476	1.07397	0.759515
15.64078	46.51481	7.096562	2.981513	10.60458	20.03311	0.048749	0.048372	1.007782	0.706322
13.90432	51.58791	6.137003	2.366811	13.43078	24.03638	0.01874	0.019717	0.950457	0.665188
12.12465	56.74189	5.272642	1.778738	16.09665	28.32095	-0.00318	-0.00351	0.904168	0.6371
10.71742	61.46307	4.481484	1.315395	18.81316	31.7456	-0.01593	-0.01846	0.863028	0.615964
16.02466	16.95758	15.1503	6.412414	0.015679	0.565227	0.628085	0.276043	2.275321	1.696066

16.36955	17.4404	13.8398	6.445106	0.128255	0.617297	0.607927	0.290309	2.094075	1.547959
16.99498	18.76248	13.99999	6.435043	0.233704	1.225949	0.478823	0.281675	1.699913	1.260855
17.28951	21.2799	17.19826	5.745127	0.737195	2.967342	0.388499	0.264259	1.470145	1.101031
20.21763	28.57126	17.85572	6.28672	2.246611	5.811858	0.28198	0.228056	1.236454	0.938529
20.38665	33.67071	15.03988	5.012573	4.536392	8.452	0.215431	0.186959	1.152288	0.866914
18.40821	36.93505	11.4404	3.488653	6.546086	11.71019	0.139052	0.125865	1.104774	0.801445
17.57558	40.21683	9.037487	3.219842	7.924414	14.45163	0.099077	0.093631	1.058161	0.760096
16.15492	43.00208	7.316683	2.902822	9.205878	17.38963	0.073999	0.073098	1.012334	0.718791
14.56979	46.8613	6.073285	2.552663	11.08578	20.97087	0.049013	0.050681	0.9671	0.681285
12.8384	51.38704	5.339215	2.150158	13.52769	24.80431	0.025533	0.027874	0.91603	0.644288
16.02466	16.95758	15.1503	6.412414	0.015679	0.565227	0.628085	0.276043	2.275321	1.696066
16.36955	17.4404	13.8398	6.445106	0.128255	0.617297	0.607927	0.290309	2.094075	1.547959
16.99498	18.76248	13.99999	6.435043	0.233704	1.225949	0.478823	0.281675	1.699913	1.260855
17.23555	21.1291	17.14294	5.724188	0.72097	2.889168	0.390129	0.264677	1.473978	1.10307
18.48908	25.46449	16.43345	6.006832	1.842997	4.851249	0.313462	0.241397	1.298538	0.976446
18.83048	28.96696	12.67072	5.292019	3.408609	6.44785	0.273394	0.225203	1.213988	0.911521
17.81583	30.72627	9.132145	4.304127	4.495187	8.135872	0.25638	0.218391	1.173953	0.875251
17.81611	33.93796	7.52753	3.68255	5.636692	10.20453	0.213279	0.191764	1.112195	0.825669
17.1193	37.16067	6.296738	3.073196	7.016066	12.74983	0.169663	0.159108	1.066338	0.780301
15.82104	38.97498	4.880448	2.678071	8.035127	14.85429	0.140415	0.134606	1.04316	0.74905
14.2116	40.19165	3.810809	2.281395	8.861905	16.86758	0.119476	0.11777	1.01449	0.717874
16.02466	16.95758	15.1503	6.412414	0.015679	0.565227	0.628085	0.276043	2.275321	1.696066
16.21874	17.29103	13.60109	6.448826	0.127523	0.619378	0.610386	0.290814	2.098887	1.550577
15.93769	17.05754	12.61464	6.344576	0.16667	0.648053	0.497729	0.286438	1.737652	1.278392
14.66147	15.86957	11.55255	6.096316	0.230934	0.691479	0.421779	0.27317	1.544021	1.119845
14.47781	15.82053	9.534411	5.921341	0.318897	0.749225	0.387362	0.264984	1.461833	1.04263
15.10057	16.54058	7.034269	5.334418	0.414163	0.765812	0.368557	0.259696	1.419185	0.990781
15.18513	16.86061	5.243946	4.678979	0.495114	0.926637	0.357538	0.258235	1.384546	0.948524
14.38194	16.31092	3.989081	4.29854	0.580646	1.099948	0.34533	0.256008	1.348901	0.906845
13.63262	15.94141	3.020356	3.927468	0.711902	1.354677	0.333304	0.253848	1.31301	0.868192
12.77657	15.47109	2.311242	3.733936	0.845073	1.613402	0.324336	0.252724	1.283358	0.835754
11.78802	14.92147	1.85178	3.370691	0.99458	1.908873	0.315302	0.252439	1.249023	0.800633
15.80697	17.84273	12.6582	4.421001	0.153727	1.569328	0.534469	0.253219	2.110704	1.634421
11.84433	20.20278	13.19054	1.382433	1.597702	5.222252	0.401137	0.230785	1.73814	1.318348
8.837917	27.30275	28.08626	1.153441	3.755404	11.99063	0.168345	0.129742	1.29754	0.979863
7.354151	30.71905	34.47532	0.728726	6.396509	14.3762	0.089493	0.082131	1.089629	0.816098
6.549924	32.96311	36.98235	0.524294	9.396815	14.68761	0.054249	0.05678	0.955422	0.703583
6.117089	33.87575	39.65232	0.41796	12.66715	13.0033	0.026504	0.030818	0.860013	0.621382
5.904022	36.31875	41.91606	0.400777	15.73404	12.78051	-0.00044	-0.00057	0.772201	0.557407
5.845282	39.77649	43.90318	0.508285	18.72478	13.46236	-0.03457	-0.04906	0.704561	0.50898
5.844488	45.62255	40.68446	0.703838	23.04646	15.10306	-0.05782	-0.08701	0.6645	0.472281
5.598358	47.78113	36.24072	0.419906	25.90907	15.08463	-0.07822	-0.11974	0.653289	0.449928
15.80697	17.84273	12.6582	4.421	0.153726	1.569329	0.534469	0.253219	2.110704	1.634421
11.84432	20.20278	13.19054	1.382435	1.597703	5.222252	0.4012	0.230786	1.738411	1.318554
9.539985	24.34445	19.98966	1.188018	3.215254	9.130521	0.24793	0.17961	1.380383	1.028684

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7.35049	33.11732	35.55286	0.604497	9.169982	14.1652	0.091002	0.094028	0.967813	0.742431
6.858954	35.88578	38.33486	0.503449	12.79574	13.99719	0.058812	0.068247	0.861763	0.654724
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6.303682	39.07584	41.47742	0.354929	18.43739	12.5722	0.009023	0.012667	0.712335	0.530669
6.266134	43.47341	41.31107	0.408466	21.86819	13.7388	-0.02159	-0.03288	0.656581	0.486721
6.088275	48.86499	38.61675	0.552127	26.29503	15.05282	-0.04534	-0.07308	0.620321	0.452431
15.80697	17.84273	12.6582	4.421	0.153726	1.569329	0.534469	0.253219	2.110704	1.634421
11.84432	20.20278	13.19054	1.382435	1.597703	5.222252	0.4012	0.230786	1.738411	1.318554
9.759592	23.14743	17.2999	1.214886	2.979619	8.096366	0.279292	0.196913	1.418352	1.053609
8.5182	27.04139	23.70065	0.861763	5.314578	10.77904	0.200445	0.168802	1.187462	0.886726
7.857063	31.41135	30.98084	0.635937	8.526609	12.6422	0.132509	0.131605	1.006873	0.768649
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7.041799	39.10198	39.20441	0.445063	16.2506	13.70554	0.05577	0.071491	0.780095	0.607302
7.198403	40.07471	40.61334	0.279512	18.62333	12.40307	0.035564	0.049465	0.718973	0.565768
7.431918	41.52757	40.75131	0.29773	20.70265	11.75765	0.029613	0.044349	0.667731	0.529035
7.303475	45.23147	39.1359	0.270609	24.0103	12.44168	0.021852	0.035212	0.620595	0.492549
15.80697	17.84273	12.6582	4.421	0.153726	1.569329	0.534469	0.253219	2.110704	1.634421
11.84432	20.20278	13.19054	1.382435	1.597703	5.222252	0.4012	0.230786	1.738411	1.318554
9.801178	21.56375	14.8097	1.273894	2.599696	7.069301	0.326509	0.219831	1.485276	1.095257
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8.460043	29.55622	23.27916	0.716063	9.818264	9.315739	0.189219	0.189511	0.998461	0.741052
8.478483	32.69375	25.89845	0.60189	12.84106	9.495384	0.158243	0.177578	0.891119	0.672592
8.554225	37.96659	29.64627	0.582044	16.37962	11.14052	0.119741	0.151533	0.790195	0.616311
8.585799	43.6945	32.80231	0.551481	20.42809	12.8645	0.086469	0.122549	0.705585	0.56729
8.31915	49.80178	34.67413	0.436037	25.49229	14.32518	0.05842	0.091864	0.635942	0.524164
15.74575	16.6407	14.85831	5.973432	0.024376	0.558151	0.562247	0.248977	2.258227	1.758602
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11.74132	19.37555	12.33374	1.584861	1.478757	4.683824	0.4171	0.235025	1.774704	1.338654
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8.463815	25.00174	19.11937	0.72449	6.354316	8.236976	0.254044	0.221342	1.147741	0.83217
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8.601616	30.54107	23.29764	0.683544	11.8213	8.371593	0.198369	0.212244	0.934631	0.688072
8.838581	34.69862	26.01733	0.695965	14.66959	9.462769	0.166481	0.197799	0.841669	0.636466
9.126039	38.54444	27.24572	0.687425	17.39128	10.37899	0.143887	0.186904	0.769846	0.593411
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16.14072	17.06175	15.28008	6.121093	0.009361	0.581308	0.622332	0.273371	2.276515	1.620412
14.60834	17.58937	13.15008	5.17228	0.30533	2.248032	0.538257	0.260458	2.066583	1.465148
10.23787	16.74596	11.56993	2.751665	1.570885	4.549952	0.389598	0.230591	1.689566	1.228875
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16.14072	17.06175	15.28008	6.121093	0.009361	0.581308	0.621449	0.272983	2.276515	1.620412
14.60834	17.58937	13.15008	5.17228	0.30533	2.248032	0.537739	0.260207	2.066583	1.465148
10.23787	16.74596	11.56993	2.751665	1.570885	4.549952	0.388236	0.229785	1.689566	1.228875
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13.1634	37.47277	20.81917	4.36E-05	9.986928	13.79956	0.071062	0.110243	0.644593	0.491405
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9.335716	73.57578	16.00799	2.1E-05	45.28064	18.72399	-0.01614	-0.04115	0.392159	0.282597
8.048955	80.22155	12.6139	1.79E-05	52.20654	19.76059	-0.01979	-0.0557	0.35522	0.257018
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16.14072	17.06175	15.28008	6.121093	0.009361	0.581308	0.621449	0.272983	2.276515	1.620412
14.60834	17.58937	13.15008	5.17228	0.30533	2.248032	0.537739	0.260207	2.066583	1.465148
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8.499425	76.0253	14.18743	1.92E-05	48.10272	19.20276	-0.01008	-0.02835	0.355461	0.261743
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16.14072	17.06175	15.28008	6.121093	0.009361	0.581308	0.621449	0.272983	2.276515	1.620412
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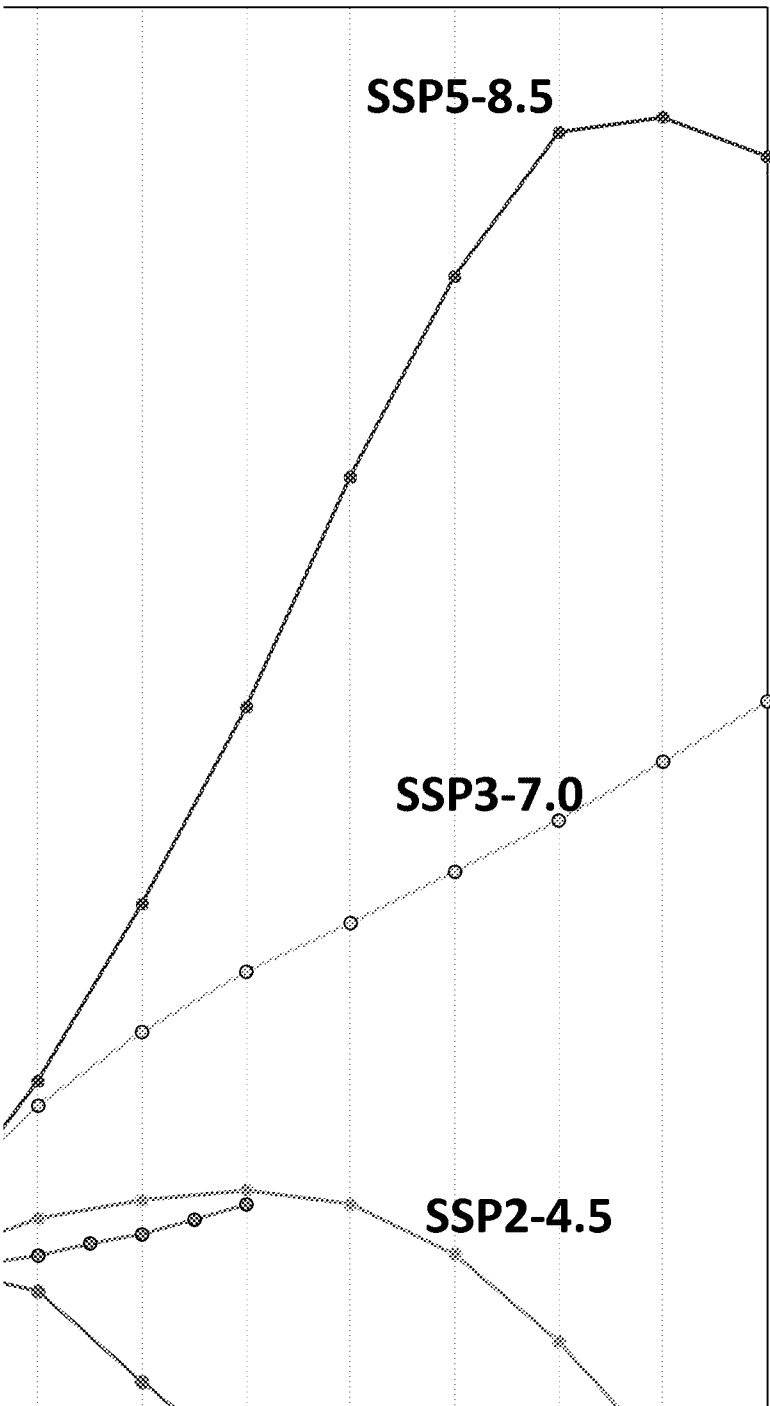
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Final
energy as

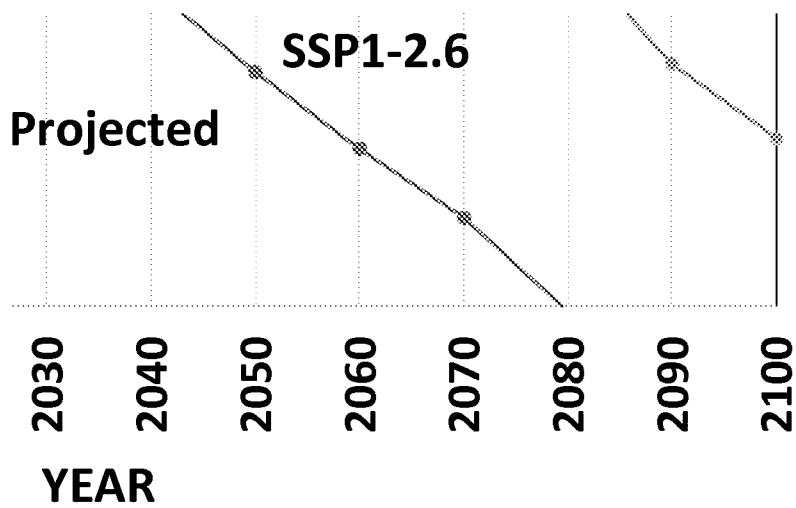
a share of
primary
energy

final_ener gy_biomass	final_ener gy_coal	final_ener gy_solar	annotatio n	primary_e nergy_inte nsity	final_ener gy_intensit y
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74.23929	37.99325	31.6265	0.016459	Sustainabil	0.007996	0.005936	SSP1 - 1.9	2005
72.60206	43.75728	39.65266	0.121414	Sustainabil	0.007389	0.005365	SSP1 - 1.9	2010
71.73168	28.30574	35.73998	1.805154	Sustainabil	0.004746	0.003404	SSP1 - 1.9	2020
69.28882	24.8782	36.5562	2.218601	Sustainabil	0.003544	0.001764	SSP1 - 1.9	2030



001295	SSP1 - 1.9	2040
001101	SSP1 - 1.9	2050
000966	SSP1 - 1.9	2060
00086	SSP1 - 1.9	2070
000772	SSP1 - 1.9	2080
000694	SSP1 - 1.9	2090
000629	SSP1 - 1.9	2100
005936	SSP1 - 2.6	2005
005365	SSP1 - 2.6	2010
003783	SSP1 - 2.6	2020
002558	SSP1 - 2.6	2030
00186	SSP1 - 2.6	2040
00147	SSP1 - 2.6	2050
001244	SSP1 - 2.6	2060
00105	SSP1 - 2.6	2070
000895	SSP1 - 2.6	2080
00079	SSP1 - 2.6	2090
000737	SSP1 - 2.6	2100
005936	SSP1 - 3.4	2005
005365	SSP1 - 3.4	2010
003881	SSP1 - 3.4	2020
002765	SSP1 - 3.4	2030
002115	SSP1 - 3.4	2040
001733	SSP1 - 3.4	2050
001467	SSP1 - 3.4	2060
001218	SSP1 - 3.4	2070
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000768	SSP1 - 3.4	2100
005936	SSP1 - 4.5	2005
005365	SSP1 - 4.5	2010
00388	SSP1 - 4.5	2020
002803	SSP1 - 4.5	2030
002213	SSP1 - 4.5	2040
001857	SSP1 - 4.5	2050



75.37708	53.76987	9.049482	117.3867	Sustainabil	0.00142	0.00107	SSP1 - Base	2090
75.40109	47.2859	6.338364	118.0513	Sustainabil	0.001239	0.000934	SSP1 - Base	2100
69.56632	38.956	27.038	0.293	Middle of t	0.008215	0.005715	SSP2 - 1.9	2005
72.34056	44.775	35.721	2.23	Middle of t	0.007407	0.005359	SSP2 - 1.9	2010
76.3517	48.623	38.558	8.824	Middle of t	0.005696	0.004349	SSP2 - 1.9	2020
83.24243	57.896	13.387	18.646	Middle of t	0.003607	0.003002	SSP2 - 1.9	2030
82.00403	52.67	0.398	27.833	Middle of t	0.002831	0.002322	SSP2 - 1.9	2040
79.67295	47.235	0.04	32.687	Middle of t	0.002463	0.001962	SSP2 - 1.9	2050
78.17842	33.067	0.001	36.245	Middle of t	0.002251	0.00176	SSP2 - 1.9	2060
77.73421	14.144	0	39.088	Middle of t	0.002029	0.001577	SSP2 - 1.9	2070
77.77272	7.201	0	40.737	Middle of t	0.001841	0.001432	SSP2 - 1.9	2080
77.40471	4.467	0	41.086	Middle of t	0.001698	0.001315	SSP2 - 1.9	2090
77.05598	4.489	0	41.327	Middle of t	0.00159	0.001225	SSP2 - 1.9	2100
69.55144	38.956	27.038	0.293	Middle of t	0.008216	0.005714	SSP2 - 2.6	2005
72.22695	44.864	35.721	2.231	Middle of t	0.00742	0.005359	SSP2 - 2.6	2010
76.39975	49.601	37.912	9.05	Middle of t	0.005679	0.004339	SSP2 - 2.6	2020
81.21782	57.611	31.198	19.841	Middle of t	0.004127	0.003352	SSP2 - 2.6	2030
81.55205	54.389	16.345	30.819	Middle of t	0.003353	0.002734	SSP2 - 2.6	2040
79.58487	50.914	6.86	37.236	Middle of t	0.002888	0.002299	SSP2 - 2.6	2050
77.84664	43.155	4.292	41.53	Middle of t	0.002602	0.002026	SSP2 - 2.6	2060
75.94345	28.18	1.089	44.537	Middle of t	0.002366	0.001797	SSP2 - 2.6	2070
76.38073	24.909	0	46.738	Middle of t	0.002133	0.001629	SSP2 - 2.6	2080
76.86084	20.003	0	47.698	Middle of t	0.001933	0.001486	SSP2 - 2.6	2090
78.02526	11.127	0	48.498	Middle of t	0.001769	0.00138	SSP2 - 2.6	2100
69.55144	38.956	27.038	0.293	Middle of t	0.008216	0.005714	SSP2 - 3.4	2005
72.22507	44.864	35.721	2.231	Middle of t	0.00742	0.005359	SSP2 - 3.4	2010
76.3303	48.464	37.969	8.889	Middle of t	0.00568	0.004336	SSP2 - 3.4	2020
79.23507	54.286	41.38	19.4	Middle of t	0.004408	0.003492	SSP2 - 3.4	2030
81.31629	56.41	38.551	31.222	Middle of t	0.003637	0.002957	SSP2 - 3.4	2040
80.71405	57.171	33.67	39.01	Middle of t	0.003149	0.002542	SSP2 - 3.4	2050
79.20049	52.13	27.042	44.061	Middle of t	0.002767	0.002192	SSP2 - 3.4	2060
78.31587	33.64	20.03	47.211	Middle of t	0.002504	0.001961	SSP2 - 3.4	2070
76.94987	19.183	7.843	49.817	Middle of t	0.002308	0.001776	SSP2 - 3.4	2080

00159	SSP1 - 4.5	2060
01344	SSP1 - 4.5	2070
00113	SSP1 - 4.5	2080
00952	SSP1 - 4.5	2090
00829	SSP1 - 4.5	2100
05936	SSP1 - Base	2005
05365	SSP1 - Base	2010
03882	SSP1 - Base	2020
02811	SSP1 - Base	2030
02241	SSP1 - Base	2040
00188	SSP1 - Base	2050
01631	SSP1 - Base	2060
01419	SSP1 - Base	2070
01233	SSP1 - Base	2080

76.52445	17.861	2.288	51.275	Middle of t	0.002109	0.001614	SSP2 - 3.4	2090
76.79779	20.99	0.116	52.505	Middle of t	0.00195	0.001498	SSP2 - 3.4	2100
69.55144	38.956	27.038	0.293	Middle of t	0.008216	0.005714	SSP2 - 4.5	2005
72.22507	44.864	35.721	2.231	Middle of t	0.007419	0.005359	SSP2 - 4.5	2010
76.24707	48.531	39.484	8.81	Middle of t	0.005694	0.004341	SSP2 - 4.5	2020
79.04371	53.793	53.068	19.039	Middle of t	0.004507	0.003562	SSP2 - 4.5	2030
80.70134	56.237	59.416	30.785	Middle of t	0.003806	0.003072	SSP2 - 4.5	2040
80.07156	56.577	57.55	40.035	Middle of t	0.003342	0.002676	SSP2 - 4.5	2050
78.91855	55.143	56.143	45.579	Middle of t	0.00295	0.002328	SSP2 - 4.5	2060
79.16838	50.258	56.04	48.923	Middle of t	0.002606	0.002063	SSP2 - 4.5	2070
79.4836	35.842	51.498	51.44	Middle of t	0.002364	0.001879	SSP2 - 4.5	2080
79.40343	22.835	36.647	52.965	Middle of t	0.002172	0.001724	SSP2 - 4.5	2090
77.7537	16.314	16.616	54.306	Middle of t	0.002055	0.001598	SSP2 - 4.5	2100
69.55159	38.956	27.038	0.293	Middle of t	0.008216	0.005714	SSP2 - 6.0	2005
72.22695	44.864	35.721	2.231	Middle of t	0.007419	0.005358	SSP2 - 6.0	2010
76.16588	48.396	40.058	8.81	Middle of t	0.005701	0.004342	SSP2 - 6.0	2020
78.34123	53.308	58.527	19.092	Middle of t	0.004601	0.003604	SSP2 - 6.0	2030
79.06991	52.905	72.354	30.211	Middle of t	0.00396	0.003131	SSP2 - 6.0	2040
77.68846	48.811	78.316	38.829	Middle of t	0.00354	0.00275	SSP2 - 6.0	2050
76.28232	49.767	86.74	46.579	Middle of t	0.00319	0.002434	SSP2 - 6.0	2060
76.12337	45.842	91.896	50.762	Middle of t	0.002837	0.002159	SSP2 - 6.0	2070
77.34939	35.626	99.397	53.526	Middle of t	0.00257	0.001988	SSP2 - 6.0	2080
78.16779	27.374	104.753	55.537	Middle of t	0.002376	0.001857	SSP2 - 6.0	2090
79.36445	32.217	103.076	57.178	Middle of t	0.0022	0.001746	SSP2 - 6.0	2100
69.55454	38.956	27.038	0.293	Middle of t	0.008215	0.005714	SSP2 - Base	2005
72.22522	44.858	35.727	2.231	Middle of t	0.007419	0.005358	SSP2 - Base	2010
75.86277	48.381	42.691	8.809	Middle of t	0.005733	0.004349	SSP2 - Base	2020
77.87315	52.933	63.242	18.902	Middle of t	0.004661	0.00363	SSP2 - Base	2030
78.20559	52.613	76.553	29.662	Middle of t	0.004038	0.003158	SSP2 - Base	2040
76.44368	47.924	85.508	38.879	Middle of t	0.003642	0.002784	SSP2 - Base	2050
74.59954	49.317	96.465	46.568	Middle of t	0.003318	0.002475	SSP2 - Base	2060
73.75047	49.562	109.512	51.295	Middle of t	0.003003	0.002214	SSP2 - Base	2070
73.22668	37.785	119.793	54.153	Middle of t	0.002793	0.002045	SSP2 - Base	2080
73.68731	24.012	123.869	56.363	Middle of t	0.002597	0.001914	SSP2 - Base	2090
74.66659	23.503	130.726	58.542	Middle of t	0.002418	0.001806	SSP2 - Base	2100
74.54186	42.4489	29.001		Regional R	0.008191	0.006106	SSP3 - 3.4	2005
73.92089	44.9529	30.2587		Regional R	0.007539	0.005573	SSP3 - 3.4	2010
74.17174	51.7927	35.6223		Regional R	0.00612	0.004539	SSP3 - 3.4	2020
75.31418	59.121	40.0743		Regional R	0.005139	0.003871	SSP3 - 3.4	2030
75.82584	64.4824	12.0058		Regional R	0.004055	0.003075	SSP3 - 3.4	2040
73.2346	69.7055	9.7741		Regional R	0.003933	0.00288	SSP3 - 3.4	2050
70.72037	74.9753	8.7745		Regional R	0.003866	0.002734	SSP3 - 3.4	2060
70.08677	80.5794	6.4582		Regional R	0.003628	0.002543	SSP3 - 3.4	2070
69.98614	86.9292	4.804		Regional R	0.003422	0.002395	SSP3 - 3.4	2080
70.46255	93.804	3.6727		Regional R	0.003255	0.002294	SSP3 - 3.4	2090
71.37246	101.6462	2.9019		Regional R	0.003107	0.002217	SSP3 - 3.4	2100
74.54186	42.4489	29.001		Regional R	0.008191	0.006106	SSP3 - 4.5	2005

73.92089	44.9529	30.2587	Regional R	0.007539	0.005573	SSP3 - 4.5	2010
74.17174	51.7927	35.6223	Regional R	0.00612	0.004539	SSP3 - 4.5	2020
74.89266	59.0726	41.3861	Regional R	0.005293	0.003964	SSP3 - 4.5	2030
75.90491	64.7857	22.3737	Regional R	0.004451	0.003379	SSP3 - 4.5	2040
75.23415	70.1531	19.1606	Regional R	0.004148	0.003121	SSP3 - 4.5	2050
72.54375	75.354	14.0575	Regional R	0.003977	0.002885	SSP3 - 4.5	2060
71.83179	81.3597	13.2908	Regional R	0.003809	0.002736	SSP3 - 4.5	2070
71.00334	88.1788	12.0531	Regional R	0.003644	0.002588	SSP3 - 4.5	2080
70.44611	95.6327	10.369	Regional R	0.003482	0.002453	SSP3 - 4.5	2090
70.33485	103.8517	8.3042	Regional R	0.003298	0.002319	SSP3 - 4.5	2100
74.54186	42.4489	29.001	Regional R	0.008191	0.006106	SSP3 - 6.0	2005
73.92089	44.9529	30.2587	Regional R	0.007539	0.005573	SSP3 - 6.0	2010
74.17174	51.7927	35.6223	Regional R	0.00612	0.004539	SSP3 - 6.0	2020
74.83623	59.0691	41.5464	Regional R	0.005306	0.003971	SSP3 - 6.0	2030
75.19577	64.9432	30.0196	Regional R	0.004675	0.003515	SSP3 - 6.0	2040
75.08484	70.4399	28.3452	Regional R	0.00437	0.003281	SSP3 - 6.0	2050
74.55587	76.0075	30.7126	Regional R	0.004226	0.003151	SSP3 - 6.0	2060
74.23778	82.0606	28.5246	Regional R	0.004004	0.002972	SSP3 - 6.0	2070
73.17573	89.0395	26.1171	Regional R	0.003839	0.002809	SSP3 - 6.0	2080
71.80588	97.0327	25.4504	Regional R	0.003755	0.002697	SSP3 - 6.0	2090
70.76208	106.2671	25.3365	Regional R	0.003652	0.002584	SSP3 - 6.0	2100
74.54186	42.4489	29.001	Regional R	0.008191	0.006106	SSP3 - Base	2005
73.87617	44.9515	30.4891	Regional R	0.007556	0.005582	SSP3 - Base	2010
73.57008	51.7704	37.0095	Regional R	0.006256	0.004602	SSP3 - Base	2020
72.5278	59.046	42.5777	Regional R	0.005558	0.004031	SSP3 - Base	2030
71.32345	65.1974	45.1695	Regional R	0.005263	0.003753	SSP3 - Base	2040
69.81339	70.9768	46.646	Regional R	0.005109	0.003567	SSP3 - Base	2050
68.50797	76.7886	47.5485	Regional R	0.004984	0.003415	SSP3 - Base	2060
67.22841	83.247	49.0407	Regional R	0.004856	0.003265	SSP3 - Base	2070
66.12225	90.6822	50.4554	Regional R	0.004727	0.003125	SSP3 - Base	2080
65.12244	99.1394	52.5132	Regional R	0.00462	0.003009	SSP3 - Base	2090
64.10075	109.0032	54.8346	Regional R	0.004496	0.002882	SSP3 - Base	2100
			Inequality - A Road Divided			SSP4 - 2.6	2005
77.43486	47.0715	49.97054	Inequality	0.007599	0.005884	SSP4 - 2.6	2010
75.84824	54.16237	57.63439	Inequality	0.006257	0.004746	SSP4 - 2.6	2020
75.517	60.35671	26.15188	Inequality	0.004671	0.003528	SSP4 - 2.6	2030
74.89686	58.67725	17.14337	Inequality	0.003923	0.002938	SSP4 - 2.6	2040
73.6411	55.22856	9.787412	Inequality	0.00344	0.002533	SSP4 - 2.6	2050
72.25267	51.3831	5.373374	Inequality	0.003096	0.002237	SSP4 - 2.6	2060
72.18422	48.54091	2.951482	Inequality	0.00278	0.002007	SSP4 - 2.6	2070
72.24069	46.63671	1.747409	Inequality	0.002536	0.001832	SSP4 - 2.6	2080
71.07323	44.07989	1.038943	Inequality	0.002392	0.0017	SSP4 - 2.6	2090
68.8712	39.21269	0.607058	Inequality	0.002352	0.00162	SSP4 - 2.6	2100
			Inequality - A Road Divided			SSP4 - 3.4	2005
77.43486	47.0715	49.97054	Inequality	0.007599	0.005884	SSP4 - 3.4	2010
75.84824	54.16237	57.63439	Inequality	0.006258	0.004747	SSP4 - 3.4	2020
74.52167	61.19682	39.63659	Inequality	0.004969	0.003703	SSP4 - 3.4	2030

75.73551	62.45115	30.11007	Inequality	0.00409	0.003097	SSP4 - 3.4	2040
76.71224	61.31555	19.63707	Inequality	0.003484	0.002673	SSP4 - 3.4	2050
75.97497	57.28701	11.40229	Inequality	0.003102	0.002357	SSP4 - 3.4	2060
75.29892	51.93248	5.993333	Inequality	0.002797	0.002106	SSP4 - 3.4	2070
74.49711	47.06265	3.217766	Inequality	0.002564	0.00191	SSP4 - 3.4	2080
74.12964	43.27613	1.853986	Inequality	0.002364	0.001752	SSP4 - 3.4	2090
72.93502	39.92146	1.099065	Inequality	0.002233	0.001629	SSP4 - 3.4	2100
			Inequality - A Road Divided			SSP4 - 4.5	2005
77.43486	47.0715	49.97054	Inequality	0.007599	0.005884	SSP4 - 4.5	2010
75.84824	54.16237	57.63439	Inequality	0.006258	0.004747	SSP4 - 4.5	2020
74.284	59.99371	48.1592	Inequality	0.005106	0.003793	SSP4 - 4.5	2030
74.67402	63.11034	40.06832	Inequality	0.004275	0.003192	SSP4 - 4.5	2040
76.34014	63.68359	29.19299	Inequality	0.003625	0.002767	SSP4 - 4.5	2050
77.51243	61.65234	18.92858	Inequality	0.003158	0.002448	SSP4 - 4.5	2060
77.84967	57.34161	10.59714	Inequality	0.002808	0.002186	SSP4 - 4.5	2070
78.6912	54.75981	8.997759	Inequality	0.002588	0.002037	SSP4 - 4.5	2080
79.22868	50.37393	7.130474	Inequality	0.002404	0.001905	SSP4 - 4.5	2090
79.36715	44.4841	4.697732	Inequality	0.002234	0.001773	SSP4 - 4.5	2100
			Inequality - A Road Divided			SSP4 - 6.0	2005
77.43486	47.0715	49.97054	Inequality	0.007599	0.005884	SSP4 - 6.0	2010
75.84824	54.16237	57.63439	Inequality	0.006258	0.004747	SSP4 - 6.0	2020
73.74097	57.22373	63.57748	Inequality	0.005347	0.003943	SSP4 - 6.0	2030
73.45851	60.68043	61.97077	Inequality	0.00458	0.003364	SSP4 - 6.0	2040
73.79947	63.08057	56.52422	Inequality	0.004015	0.002963	SSP4 - 6.0	2050
74.21943	63.82191	49.33873	Inequality	0.003594	0.002668	SSP4 - 6.0	2060
75.47724	63.71131	40.15679	Inequality	0.003208	0.002421	SSP4 - 6.0	2070
77.99471	62.1529	30.4646	Inequality	0.002845	0.002219	SSP4 - 6.0	2080
80.39996	58.70827	21.06467	Inequality	0.00254	0.002042	SSP4 - 6.0	2090
82.42321	53.8546	13.17839	Inequality	0.002289	0.001887	SSP4 - 6.0	2100
77.87534	43.50631	43.35295	Inequality	0.00813	0.006331	SSP4 - Base	2005
77.43486	47.0715	49.97054	Inequality	0.007599	0.005884	SSP4 - Base	2010
75.42972	52.39303	61.11613	Inequality	0.006389	0.004819	SSP4 - Base	2020
72.97081	56.35663	65.39404	Inequality	0.005434	0.003965	SSP4 - Base	2030
72.37758	59.3894	64.88929	Inequality	0.004686	0.003392	SSP4 - Base	2040
72.50499	61.18852	60.96774	Inequality	0.004132	0.002996	SSP4 - Base	2050
72.6395	61.6889	56.02199	Inequality	0.003732	0.002711	SSP4 - Base	2060
73.61966	61.62037	49.51178	Inequality	0.003365	0.002477	SSP4 - Base	2070
75.61954	59.99508	43.32791	Inequality	0.00303	0.002291	SSP4 - Base	2080
77.0818	57.5097	37.25615	Inequality	0.002771	0.002136	SSP4 - Base	2090
78.21898	54.76594	32.0499	Inequality	0.002566	0.002007	SSP4 - Base	2100
71.17951	48.46	36.6	Fossil-fuel	0.008195	0.005833	SSP5 - 1.9	2005
70.89716	50.06	41.06	Fossil-fuel	0.00744	0.005275	SSP5 - 1.9	2010
72.73314	49.15	30.63	Fossil-fuel	0.006082	0.004424	SSP5 - 1.9	2020
77.37032	35.31	13.33	Fossil-fuel	0.00392	0.003033	SSP5 - 1.9	2030
77.29992	21.58	6.191	Fossil-fuel	0.002508	0.001939	SSP5 - 1.9	2040
71.68067	12.3	3.486	Fossil-fuel	0.00211	0.001512	SSP5 - 1.9	2050
70.46106	5.776	1.428	Fossil-fuel	0.001743	0.001228	SSP5 - 1.9	2060

71.25971	2.513	1.163	Fossil-fuel	0.001541	0.001098	SSP5 - 1.9	2070
71.96486	1.05	1.073	Fossil-fuel	0.001393	0.001002	SSP5 - 1.9	2080
73.25897	0.8238	0.8616	Fossil-fuel	0.001259	0.000922	SSP5 - 1.9	2090
74.07509	0.6644	0.7162	Fossil-fuel	0.001137	0.000843	SSP5 - 1.9	2100
71.17951	48.46	36.6	Fossil-fuel	0.008195	0.005833	SSP5 - 2.6	2005
70.89716	50.06	41.06	Fossil-fuel	0.00744	0.005275	SSP5 - 2.6	2010
72.73314	49.15	30.63	Fossil-fuel	0.006082	0.004424	SSP5 - 2.6	2020
76.18038	36.24	14.75	Fossil-fuel	0.004295	0.003272	SSP5 - 2.6	2030
78.56076	23.07	7.691	Fossil-fuel	0.002894	0.002273	SSP5 - 2.6	2040
76.23483	14.21	5.413	Fossil-fuel	0.002321	0.001769	SSP5 - 2.6	2050
71.52393	7.563	3.276	Fossil-fuel	0.001938	0.001386	SSP5 - 2.6	2060
71.12014	4.211	2.845	Fossil-fuel	0.001622	0.001154	SSP5 - 2.6	2070
72.06164	2.828	2.839	Fossil-fuel	0.001412	0.001017	SSP5 - 2.6	2080
72.3546	2.665	2.713	Fossil-fuel	0.001279	0.000925	SSP5 - 2.6	2090
72.49781	2.424	2.493	Fossil-fuel	0.00117	0.000848	SSP5 - 2.6	2100
71.17951	48.46	36.6	Fossil-fuel	0.008195	0.005833	SSP5 - 3.4	2005
70.89716	50.06	41.06	Fossil-fuel	0.00744	0.005275	SSP5 - 3.4	2010
72.73314	49.15	30.63	Fossil-fuel	0.006082	0.004424	SSP5 - 3.4	2020
75.41574	38.07	19.4	Fossil-fuel	0.004379	0.003302	SSP5 - 3.4	2030
77.64706	26.54	12.89	Fossil-fuel	0.003057	0.002374	SSP5 - 3.4	2040
77.45425	17.49	9.316	Fossil-fuel	0.002445	0.001894	SSP5 - 3.4	2050
74.32662	10.27	5.923	Fossil-fuel	0.002038	0.001515	SSP5 - 3.4	2060
72.69406	5.55	4.271	Fossil-fuel	0.001688	0.001227	SSP5 - 3.4	2070
73.02326	3.783	3.783	Fossil-fuel	0.001447	0.001056	SSP5 - 3.4	2080
73.63469	3.875	4.317	Fossil-fuel	0.00128	0.000942	SSP5 - 3.4	2090
74.18584	3.692	4.657	Fossil-fuel	0.001145	0.00085	SSP5 - 3.4	2100
71.17951	48.46	36.6	Fossil-fuel	0.008195	0.005833	SSP5 - 4.5	2005
70.89716	50.06	41.06	Fossil-fuel	0.00744	0.005275	SSP5 - 4.5	2010
72.73314	49.15	30.63	Fossil-fuel	0.006082	0.004424	SSP5 - 4.5	2020
75.26808	39.58	20.75	Fossil-fuel	0.004411	0.00332	SSP5 - 4.5	2030
77.36247	28.95	17.19	Fossil-fuel	0.003141	0.00243	SSP5 - 4.5	2040
76.81947	20.35	12.39	Fossil-fuel	0.002576	0.001979	SSP5 - 4.5	2050
73.99024	13.64	9.248	Fossil-fuel	0.002197	0.001625	SSP5 - 4.5	2060
72.51381	8.381	7.024	Fossil-fuel	0.001842	0.001336	SSP5 - 4.5	2070
73.50263	6.209	6.216	Fossil-fuel	0.00158	0.001161	SSP5 - 4.5	2080
75.03419	5.438	6.165	Fossil-fuel	0.001355	0.001017	SSP5 - 4.5	2090
76.13934	4.437	6.142	Fossil-fuel	0.001206	0.000918	SSP5 - 4.5	2100
71.17951	48.46	36.6	Fossil-fuel	0.008195	0.005833	SSP5 - 6.0	2005
70.89716	50.06	41.06	Fossil-fuel	0.00744	0.005275	SSP5 - 6.0	2010
72.73314	49.15	30.63	Fossil-fuel	0.006082	0.004424	SSP5 - 6.0	2020
74.49318	39.19	25.41	Fossil-fuel	0.004563	0.003399	SSP5 - 6.0	2030
75.70892	30.28	26.77	Fossil-fuel	0.0034	0.002574	SSP5 - 6.0	2040
74.81481	23.47	22.89	Fossil-fuel	0.002841	0.002126	SSP5 - 6.0	2050
71.91453	17.78	16.7	Fossil-fuel	0.002478	0.001782	SSP5 - 6.0	2060
71.71888	12.9	12.81	Fossil-fuel	0.002088	0.001497	SSP5 - 6.0	2070
73.73041	10.02	10.11	Fossil-fuel	0.00175	0.00129	SSP5 - 6.0	2080
75.50781	7.862	7.862	Fossil-fuel	0.001471	0.00111	SSP5 - 6.0	2090

76.51976	6.603	6.752	Fossil-fuel	0.00129	0.000987	SSP5 - 6.0	2100
71.17951	48.46	36.6	Fossil-fuel	0.008195	0.005833	SSP5 - Base	2005
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71.87301	49.33	32.12	Fossil-fuel	0.006151	0.004421	SSP5 - Base	2020
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63.82488	12.48	13.51	Fossil-fuel	0.002344	0.001496	SSP5 - Base	2080
63.56546	9.746	9.876	Fossil-fuel	0.002034	0.001293	SSP5 - Base	2090
63.98026	6.99	7.858	Fossil-fuel	0.001769	0.001132	SSP5 - Base	2100

CO2 emissions converted to MMtCO2	Mauna Loa CO2		NatlFossil C Emissions from ...converted to GCP 2023 MMTCO2		
29,394.2	1959	315.98	1970	4.066354923	14250.12951
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17,442.7	1962	318.45	1973	4.662962036	16340.87879
5,342.8	1963	318.99	1974	4.642759739	16270.08189
1,609.8	1964	319.62	1975	4.654135542	16309.94724
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-2,441.2	1966	321.37	1977	5.04875388	17692.84729
-5,286.8	1967	322.18	1978	5.204500693	18238.64624
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-11,956.1	1969	324.62	1980	5.318920417	18639.61859
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35,748.0	1972	327.46	1983	5.183381668	18164.63675
33,774.3	1973	329.68	1984	5.362391217	18791.95761
26,247.5	1974	330.19	1985	5.543641273	19427.1301
19,333.1	1975	331.13	1986	5.626354583	19716.99053
13,000.1	1976	332.03	1987	5.79969285	20324.43695
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13,161.4	1989	353.2	2000	6.962487117	24399.33184
1,222.9	1990	354.45	2001	7.015909784	24586.54617
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-6,872.4	2022	418.53			
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127,628.0

EIA 2023 Projections by region (MMT of CO₂, not carbon)2022 U.S. number update from April 2024 report, Table 2: <https://www.eia.gov/outlooks/230822.081459>

International Energy Outlook 2023

Release date: October 2023

Table A10. World carbon dioxide emissions by region, Reference case

million metric tons of carbon dioxide

Region	2022	2025	2030	2035	2040	2045	2050
Americas	6,992	6,746	6,251	6,238	6,353	6,513	6,674
United States	4,941	4,542	3,999	3,891	3,865	3,896	3,938
Canada	548	543	516	534	562	593	624
Mexico	419	428	446	459	482	503	526
Brazil	439	467	486	490	497	498	503
Other Americas	743	765	803	865	947	1,023	1,083
Europe and Central Asia	6,367	6,409	6,256	6,263	6,360	6,586	6,815
Western Europe	3,808	3,819	3,657	3,585	3,538	3,608	3,672
Russia	1,817	1,833	1,825	1,862	1,932	2,005	2,077
Eastern Europe and Central Asia	742	757	774	816	891	974	1,066
Asia Pacific	18,705	19,121	20,318	21,051	21,375	21,842	22,405
Japan	1,039	1,019	864	821	782	762	739
South Korea	639	649	649	648	641	636	630
Australia	404	395	422	433	438	449	461
China	11,500	11,530	11,644	11,594	11,150	10,788	10,601
India	2,447	2,677	3,408	3,860	4,328	4,807	5,210
Other Asia Pacific	2,676	2,851	3,331	3,695	4,035	4,401	4,765
Africa and the Middle East	3,606	3,776	3,900	4,172	4,408	4,744	5,060
Africa	1,331	1,380	1,504	1,697	1,837	2,066	2,283
Middle East	2,275	2,396	2,397	2,474	2,571	2,678	2,777
World	35,669	36,053	36,726	37,724	38,497	39,685	40,954

Data source: U.S. Energy Information Administration, World Energy Projection System
 r_230822.081459 and Annual Energy Outlook 2023 (March 2023), www.eia.gov/aeo

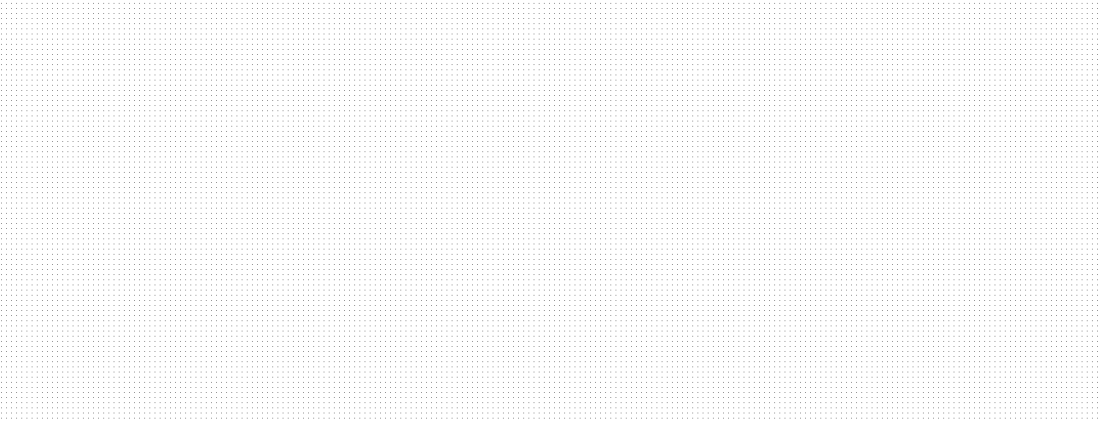
Note: Totals may not equal sum of components due to independent rounding.











/www.eia.gov/environment/emissions/carbon/pdf/2023_Emissions_Report.pdf

Average annual percentage change,
-0.166%
-0.736%
0.462%
0.817%
0.491%
1.354%
0.243%
-0.130%
0.480%
1.300%
0.647%
-1.210%
-0.051%
0.473%
-0.290%
2.736%
2.081%
1.218%
1.945%
0.716%
0.495%
(2023), run



From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Friday, May 16, 2025 3:08 PM
To: Ross McKittrick
Cc: Steven Koonin; Judith Curry; John Christy; Roy W. Spencer
Subject: Report formatting/structure

Hi all,

I've gone through and made a first round of changes to the chapter and section numbering. I say first round because I'm sure I missed things (especially the references within the body that cite figures and tables in other sections, etc.), and I'll keep checking. Once we combine the chapters into a single document, we might want to create a live/linkable table of contents with section headings that renumber automatically.

We should also figure out a consistent style for fonts, colors, etc.--obviously not a top priority right now, but here's the example I would offer regarding style (this is the DOE report I led in 2017): https://www.energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf Something to think about.

The following two sentences from the end of Chapter 3 could work well in Chapter 13: "The practice of referring to unilateral US reductions as 'combatting climate change' or 'taking action on climate' reflects a profound misunderstanding of the scale of the issue. The scale problem is compounded by recognizing that U.S. motor vehicles account only for about 4 percent of global CO2 emissions so that even a fifty percent reduction in those emissions would have a vanishingly small effect on the global climate."

Given that Chapter 13 is very thin, we could also combine Chapters 12 and 13 and rename it something like "Climate Change and the US Economy."

Any thoughts/reactions?

Best,
Travis

From: Ross McKittrick [ross.mckittrick@gmail.com]
Sent: 6/8/2025 8:34:53 PM
To: Roy W. Spencer [roywspencer@hotmail.com]; Judith Curry [curry.judith@gmail.com]; John Christy [climateman60@gmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]; Steven Koonin [steven.koonin@gmail.com]; Josh Loucks [loucksj14@gmail.com]
Subject: Report structure
Attachments: NCAS.Review.[RM].June8.docx

In the attached I have included a few interior sections I wrote on topics like emergent constraints, ECS, use of ad hoc time scales, etc., and then I decided to try to do some exterior framing using Steve's existing outline. Some of the topics that have been proposed might work either as rooms within wings or as entire wings. For instance the Overconfidence topic might fit in as examples of oversimplifications, in which case maybe the title I have applied to chapter 3 could be changed to Overconfidence when Stating Conclusions.

Also, in thinking about a concluding chapter, while we aren't in a position to make a legal ruling I'd like us to at least write some things down that should be considered by those who are. We can also offer thoughts as expert readers of the report and as citizens interested in good policy.

I didn't incorporate all the material currently in circulation but if we can tweak the attached structure we could soon converge on an overall report structure and then everyone can populate it with the material now available.

Review of the Fifth National Climate Assessment

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1 INTRODUCTION

1.1 About this Report

This report responds to a request from OSTP Director Michael Kratsios (reproduced in Appendix XX) that we assess the suitability of the Fifth National Climate Assessment for informing climate and energy policies.

To conduct this assessment we reviewed NCA5 itself, NASEM review of the Third Order Draft and the USGCRP responses to the review. We have drawn upon our long experience working on advisory reports, including for the NASEM, IPCC and other organizations, as writers, reviewers and project leaders.

We find that NCA5 should not be relied on for policy making as it is an incomplete and misleading picture of our understanding of the changing climate and the risks it poses to the nation. NCA5 was selective and incomplete in its survey of the science as of its publication date in 2023 and has become even more so in the years since. We have reviewed many key scientific developments in a separate report to Energy Secretary Wright (Climate Working Group 2025, herein denoted “CWG25”). The overall effect of its biases and omissions is an excessively dire picture of climate risk.

Our report begins with background on the National Climate Assessments. We then discuss the standards by which we have assessed NCA5, followed by specific deficiencies that we have ~~we’ve~~ identified.

1.2 About the National Climate Assessments

The U.S. Global Change Research Program (USGCRP) was established by Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act (GCRA) of 1990 to develop and coordinate “a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.”

The National Climate Assessment (NCA) Reports evolved from the GCRA requirement to

Prepare and submit to the President and the Congress an assessment which (1) integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings; (2) analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and (3) analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.

The five NCA Reports to date have interpreted this mandate in different ways:

- NCA1 (2000) was a multidisciplinary effort to study and portray in regional detail the potential effects of human-induced global warming on the United States.
- NCA2 (2009) was a relatively short report that not only focused on the potential consequences of climate change, but also sought to identify potential adaptation measures and identify the highest priorities for future research.

- NCA3 (2014) was an expanded effort that continued along the lines of NCA2, and was distinguished by a comprehensive review process, including a review by the National Academy of Sciences.
- NCA4 (2017/2018) was an expanded effort published in two volumes: I Climate Science Special Report, and II Impacts, Risk, and Adaptation in the United States. This was the first NCA report to devote significant effort to assessing climate science. NCA4 introduced a traceability analysis for each key finding, including a cursory description of uncertainties.
- NCA5 (2023) returned to a single volume format, reducing discussion of climate science to a cursory two chapters, with continuing with a focus on regional and sectoral impacts of climate change. NCA5 expanded its remit to topics that are arguably outside the purview of the USGCRP, focusing on “Climate Action” and policy recommendations with a social justice emphasis. NCA5’s self-description is reproduced as Appendix II.

These successive interpretations of the NCA are poorly aligned with the GCRA’s statutory requirements. Only NCA4 gives serious consideration to climate science, which receives the great majority of USGCRP funding, and even then misrepresents some important points (see the Box nearby for an example). Natural climate variability is essentially dismissed as unimportant in NCA4 and barely mentioned in NCA5 in most contexts, despite the mandate to include both human-caused and natural climate change. Most significantly, NCA5 has redirected the focus away from climate science and even the hazard elements of impacts, towards evaluation of societal vulnerabilities and advocacy for particular policy options, especially wind and solar power. The cover image for the NCA5 Report is the installation of a solar panel.

START BOX

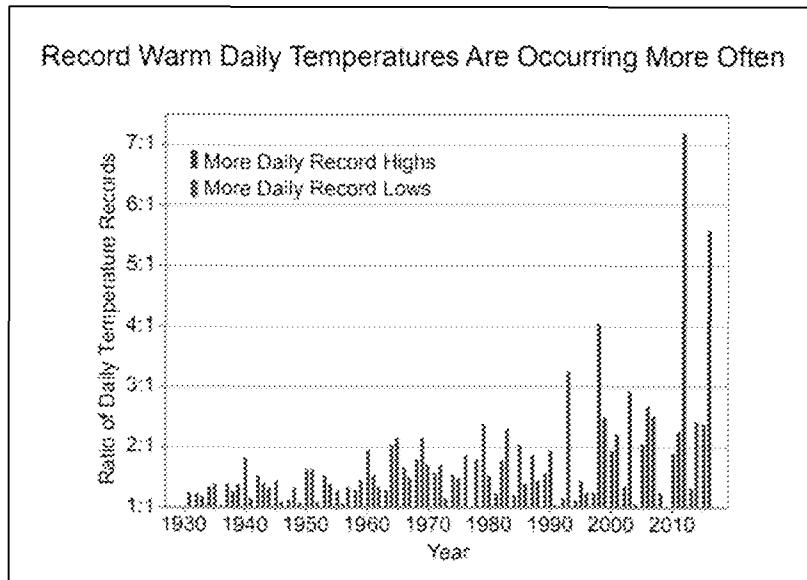
NCA4’s Figure ES.5: A Tale of Deception and Review Failure

A disappointing example of NCA4’s misrepresentation of climate science involves U.S. temperature extremes. Here is a summary of the issue; details can be found in Koonin (2024).

NCA4’s Part I (Climate Science Special Report, CCSR) says (prominently and with *Very High Confidence*) on Page 19 of the Executive Summary:

There have been marked changes in temperature extremes across the contiguous United States. The number of high temperature records set in the past two decades far exceeds the number of low temperature records.

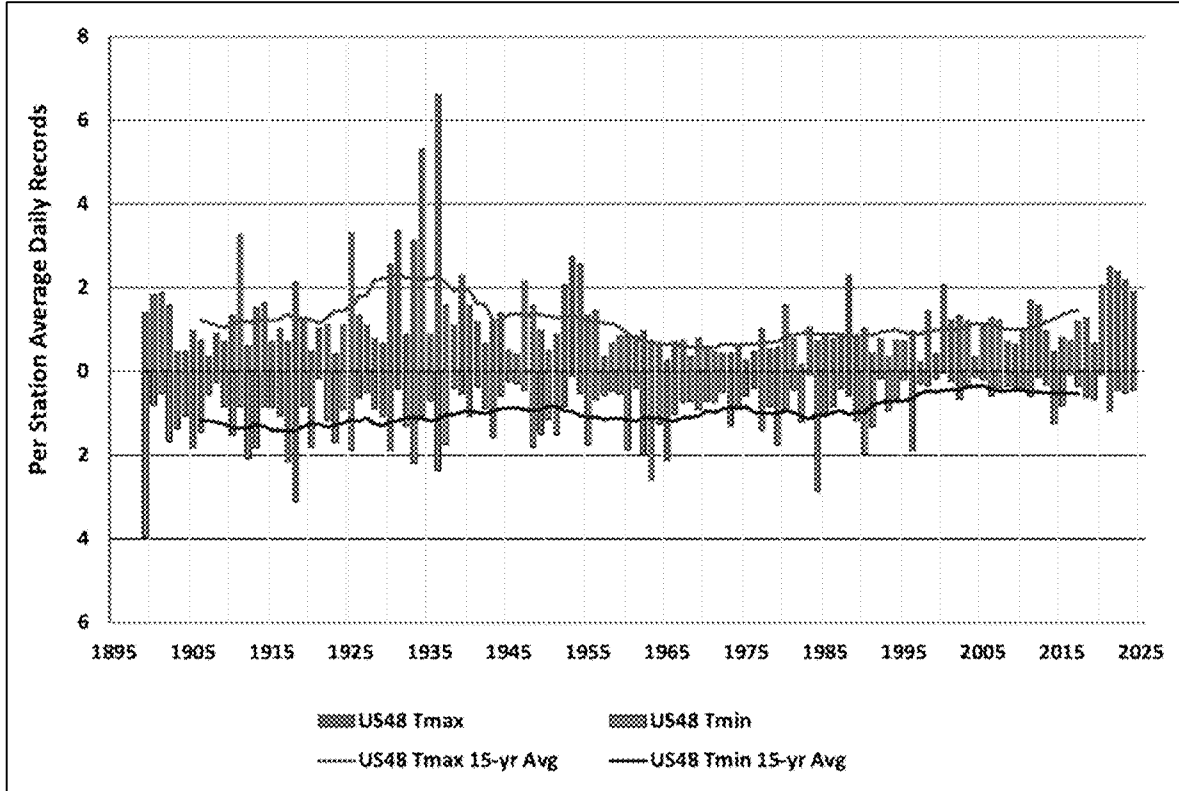
and offers this figure in support:



CSSR Figure ES.5 The ratio of the number of daily record high temperatures to daily record low temperatures for many stations across the 48 contiguous states is shown for each year from 1930 to 2017. The lighter bars show a year in which there were more record highs than lows, while the darker bars show years in which there were more record lows than highs. The height of the bar indicates the ratio of record highs to record lows for each year. For example, a ratio of 2:1 for a dark bar means that the stations had twice as many record daily lows as record daily highs for that year. (CSSR, 2017)

Three idiosyncratic choices combine to generate the figure's seemingly alarming rise in recent decades. First, because the record extremes tallied are defined conventionally (i.e., each more extreme than any preceding value in the history), the numbers of record highs and record lows are both expected to decline through the years (it becomes increasingly unlikely that a record will be exceeded). Second, the graph displays not the numbers of record highs and lows, but rather their ratio. And finally, the history begins only in 1930 when, in fact, data exist beginning in the late 19th Century. The upshot of these choices is that the resultant figure is guaranteed to show a long period of quiescence around followed by dramatic variations, creating the impression of large changes in recent decades, even if they aren't present.

Figure 6.3.3 of our report (reproduced below) shows the results of a proper analysis – defining each record as the singular extreme in the history, displaying numbers of warm and cold records separately, and beginning the analysis in 1899 rather than 1930. It makes evident the exceptional heat of the 1920s and especially the 1930s, peaking in 1936. The increased heat of the past five years is too brief to be deemed climatically significant and, in any event, occurred after the CSSR was published in 2017. On the cold side, the Valentine's Day Arctic outbreak in Feb 1899 stands as the most extensive cold extreme experienced by CONUS, with 1917 in 2nd place. The frequency of cold records has declined, especially over the last quarter of the period in which only 13 percent of the extreme cold events were measured. In contrast, 25 percent of the extreme Tmax records were achieved in the last quarter, in accordance with statistical expectations. As a result, the ratio shown in the CSSR explodes in recent decades. And the overall reduction in numbers of both cold and hot extremes over the past century indicates a climate *less* prone to extremes, in sharp contrast to the title of the CSSR figure, "Record Warm Daily Temperatures Are Occurring More Often".



Number of daily record High (red) and Low (blue) temperatures for warm and cold seasons in the CONUS. The lines represent the 15-year running, centered average. Source: 1,211 USHCN stations supplemented as needed to achieve a minimum of 92 percent of observations in the 126-year period since Dec 1898. US48: contiguous U.S. states. Tmax: maximum temperature. Tmin: minimum temperature.

The National Academies' expert review panel criticized the discussion of temperature extremes in a late draft of the CSSR. In reference to the CSSR's Key Finding 2 of Chapter 6, they said:

Further, it is difficult to understand how a statement that includes increases in extreme warmth can be associated with a high confidence or extremely likely statement, given that most of the graphics in this chapter show a decrease in extreme warmth in the historical record.

The Federal official in charge of the CSSR (Michael Kuperberg, Executive Director of the USGCRP) responded to the Academies' review by noting that

Almost every recommendation from the NAS was incorporated [in the final version]... and a new figure was added on changes in record high and low temperatures

The "new figure" referred to is the Figure ES.5, which did not appear in the draft reviewed by the Academies' panel. It seems unlikely that the Academies panel ever saw that figure because they surely would have commented if they had and it wouldn't have survived to publication. And the

figure's problems were evidently not flagged (or were ignored) in the subsequent internal government reviews.

While the following statement has far less headline potential than that from the CSSR's page 19 quoted at the beginning of this box, it has advantage of being correct:

There have been some changes in temperature extremes across the contiguous United States. The annual number of high temperature records set shows no significant trend over the past century nor over the past 40 years, but the annual number of record cold nights has declined by a factor of 4 since 1895, somewhat more rapidly in the past 30 years.

END BOX

1.3 Standards for Assessing NCA Products

Good climate and energy policies will balance the risks and benefits of a changing climate against the world's growing demand for reliable and affordable energy. To strike that balance, policymakers must understand at least two complex and nuanced topics –the certainties and uncertainties of climate science and the technoeconomic realities of energy systems. Experts in those subjects are the only people who can bring the facts to the discussion and so have a unique responsibility to communicate their understanding to non-experts clearly, completely, and without bias.

Expertise in energy systems resides largely in the private sector, where it is essential to providing the reliable and affordable energy services that are the lifeblood of society. Understanding is therefore continually refined and tested by the discipline of the marketplace. In contrast, climate science expertise is found largely in the non-profit realm of universities and government laboratories and so has a more academic character.

Because climate is at the core of human existence, it can engender passion and emotion. Indeed, some younger climate scientists have gone into the field to “save the planet.” So it isn't surprising that objectivity can suffer when climate scientists communicate their understanding to non-experts. Further, the field of climate science has been politicized by NetZero mandates. ~~When that happens,~~ This lack of objectivity usurps the public's right to make informed choices and undermines their confidence in the scientific enterprise.

Philip Handler, President of the National Academy of Sciences, identified the problem in a 1980 editorial that resonates eerily four decades later:

Difficulty arises in the scientific community from confusion of the role of scientist *qua* scientist with that of scientist as citizen, confusion of the ethical code of the scientist with the obligation of the citizen, blurring the distinction between intrinsically scientific and intrinsically political questions. When scientists fail to recognize these boundaries, their own ideological beliefs, usually unspoken, easily becloud seemingly scientific debate.

In Appendix XX we include a letter of guidance from the Office of General Counsel, U.S. Department of Energy, summarizing the extent of statutory requirements governing USGCRP work products in general and NCA products in particular.

We can summarize the standards applicable to the NCA as follows:

- details.

Beyond the statutory requirements we draw attention to two other pertinent standards. President Trump's executive order of May 23, 2025, "Restoring Gold Standard Science" enumerates some of the characteristics of good science:

- i. reproducible;
- ii. transparent;
- iii. communicative of error and uncertainty;
- iv. collaborative and interdisciplinary;
- v. skeptical of its findings and assumptions;
- vi. structured for falsifiability of hypotheses;
- vii. subject to unbiased peer review;
- viii. accepting of negative results as positive outcomes; and
- ix. without conflicts of interest.

Although these should be self-evident to those trained in science, it is surprising that some have found them controversial.

Finally we consider that when scientific reports are being assembled that will be highly influential on climate policymaking there are other desiderata, including statements about the strength of climate knowledge. The IPCC's approach is based on judgment of the available evidence and agreement among experts. More sophisticated knowledge characterizations for risk management include: REFERENCE AVEN

- The degree to which the assumptions made are reasonable/realistic based on background knowledge—concern about the focus on implausible emissions scenarios RCP8.5/SSP5–8.5
- The degree to which data/information exists and are reliable and relevant—the historical and paleo database is inadequate for a complete characterization of natural climate variability on multi-decadal to millennial time scales
- The degree to which there is disagreement among experts (including those from different environments or academic fields)—attempts to suppress disagreement and alternative perspectives among experts
- The degree to which the phenomena involved are understood and accurate models exist—concerns about the fidelity and utility of climate models
- The degree to which the knowledge has been thoroughly examined with respect to unknown knowns and—neglect of the unknown knowns associated with natural climate variability

With this background we now present our critique of NCA5.

2 OVERVIEW CHAPTER: HYPERBOLIC ADVOCACY LANGUAGE AND NON-SCIENTIFIC TONE

The opening Chapter 1 “Overview” holds a prominent place since it serves as a summary of the whole report and is all that many will read. While there is much sound scholarly content in the later sections of NCA5, Chapter 1 is marred by pervasive use of advocacy language and a tone overly focused on promoting aggressive emission reduction policies. The authors must have known this chapter would be mined for quotes by the media and activists looking to add an imprimatur of scientific authority to oversimplified declarations of opinion. Many examples can be cited; here we provide a few particularly egregious ones.

The chapter opens as follows:

The more the planet warms, the greater the impacts. Without rapid and deep reductions in global greenhouse gas emissions from human activities, the risks of accelerating sea level rise, intensifying extreme weather, and other harmful climate impacts will continue to grow. Each additional increment of warming is expected to lead to more damage and greater economic losses compared to previous increments of warming, while the risk of catastrophic or unforeseen consequences also increases.

This statement presupposes all warming is anthropogenic in origin, all warming is bad and causes economic damage, warming causes extreme weather to intensify. Such sweeping generalizations go well beyond what science has or can establish. A scientifically-sound version of this paragraph would instead say something like the following:

The Earth is undergoing a warming trend caused by a combination of natural and anthropogenic influences. This warming can be expected to generate a mix of benefits and harms that varies by region, to which society should be prepared to adapt. There is evidence that some types of extreme weather have worsened, while others have not changed or have even declined in intensity. Reducing emissions of greenhouse gases can slow the warming process although such policies have proven to be very expensive, so the costs need to be weighed against the potential benefits.

On the next page the Overview goes on to say:

Each additional increment of warming leads to greater risks [here it lists 7 key components of society including food security and the economy]... Without deeper cuts in global net emissions, climate risks to the US will continue to grow... Action to limit future warming and reduce risks can have near-term benefits and opportunities: low-carbon energy jobs, Improved air quality, Health benefits, Economic benefits...”

The authors write as if climate policy does not involve trade-offs and all measures to reduce future warming will be effective and beneficial. But the vast body of scholarship on climate science and economics does not support such simplistic claims. Not every additional increment of warming leads to economic harms, indeed (as is acknowledged in Chapter 19 on Economics) in some cases it

is expected to yield benefits. Nor is climate policy guaranteed to create jobs or benefit the economy; in many cases it has done the opposite. It is a disservice to policymakers not to be honest about this.

Page 9 promotes renewable energy options by arguing that the “levelized” costs of wind and solar power generation have fallen sharply since 2010. But “levelized” refers to the lifetime project cost averaged over all power production and ignores the intermittency problem: namely solar and wind are not always available. It results in an invalid comparison since even if, for instance, the levelized cost of solar energy per megawatt-hour falls below that of coal, coal power is available continuously and on demand whereas solar is not. The proper comparison would adjust for the difference in availability by considering the cost of supplementing solar and wind with backup natural gas-fired systems or battery storage, and on that basis renewable energy remains prohibitively expensive. Here again it is a disservice to readers not to acknowledge these facts.

Page 14 presents future emission scenarios with the following description: “Climate modeling experts develop global climate projections for a range of plausible futures.” The word “plausible” is applied to all the scenarios. The accompanying Figure includes both SSP3-7.0 and SSP5-8.5, the latter reaching the same radiative forcing as RCP8.5. The figure does not contrast observed emissions against model projections nor does it caution readers that SSP3-7.0 and SSP5-8.5 are extreme worst case scenarios that, like RCP8.5, have been heavily criticized in the scientific literature (CWG25 3.2.1). By describing the entire envelope of emission projections as “plausible” the report opens the door to later presenting impacts associated with extreme and implausible emission scenarios as part of a baseline “business-as-usual” future.

Page 17 (and elsewhere) invokes the NOAA Billion Dollar Dataset as an indicator of weather getting worse. Scientists have shown that this is an invalid metric (CWG 10.2) since it measures the growth of the economy not the frequency of extreme weather, and indeed NOAA has withdrawn the data product. Even though it was still distributed by NOAA at the time of the NCA5, the report authors should have assessed it skeptically and seen that it was unfit for the purpose of measuring climate trends.

Page 23 states, in large font:

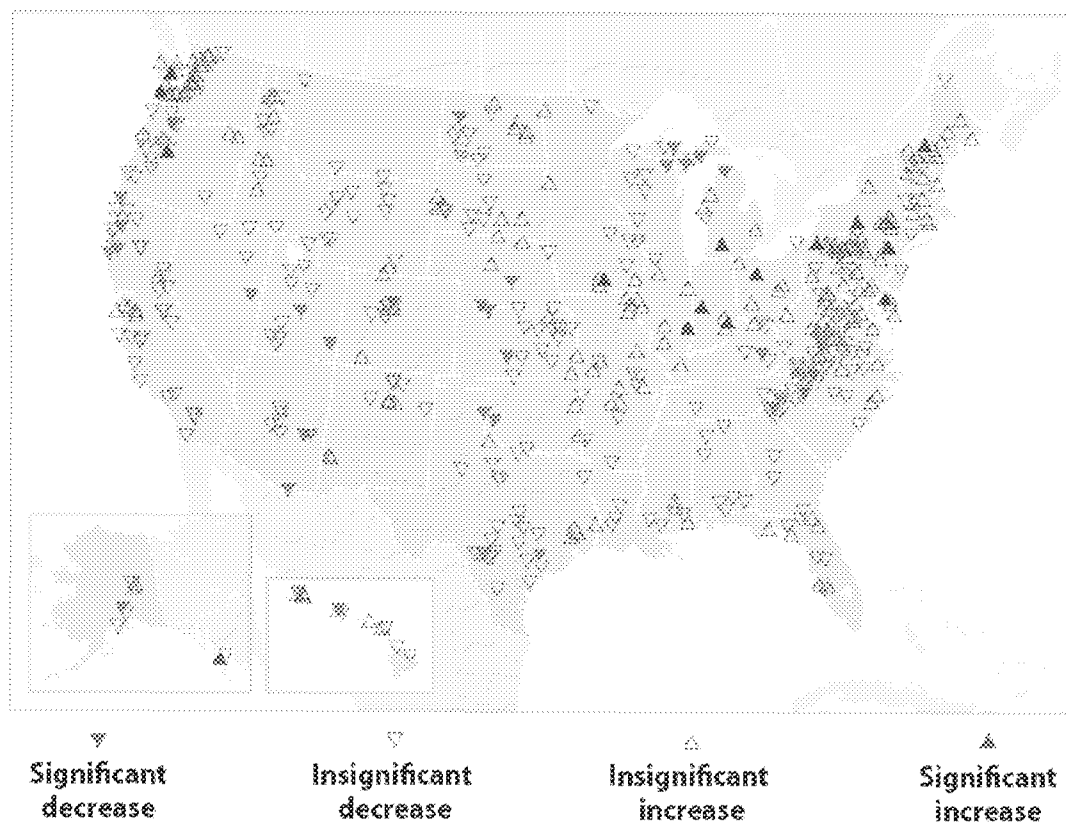
Climate changes are making it harder to maintain safe homes and healthy families; reliable public services; a sustainable economy; thriving ecosystems, cultures, and traditions; and strong communities.

It is pointless to try to evaluate this statement on scholarly grounds; it is self-evidently hyperbolic. This kind of language doesn’t belong in a scientific assessment report. Its prominent inclusion points not only to the willingness of NCA5 authors to promote hysteria, but also the ineffectiveness of the review process at not ensuring such statements are removed.

We won’t try to cite all the remaining examples of advocacy and hyperbole in the Overview chapter; one more example will suffice. Page 26 states “Increasing flooding puts more people and assets at risk.” The accompanying figure contrasts model-projected flood losses by county in 2050 to that observed in 2020 as estimated in Wing *et al.* (2022)¹. Hence the evidence for the claim is not currently-observed trends, it is a model-generated projection of changes. But current trends in U.S.-based flooding reveal a more complex picture with a general overall trend towards less flooding.

¹ Wing, Oliver, William Lehman, Paul Bates *et al.* (2022) Inequitable patterns of US flood risk in the Anthropocene. *Nature Climate Change* 12 156—162 <https://www.nature.com/articles/s41558-021-01265-6>

The Environmental Protection Agency's "Climate Change Indicators: River Flooding" webpage² shows maps both of flood magnitude and frequency. Both show more regions experiencing declines over 1965-2015 than increases. Hence current trends indicate generally declining U.S. flood risks, but the NCA5 Overview not only fails to mention this but declares the opposite based on a single study presenting model-generated forecasts of flood activity decades in the future.



U.S. Flood magnitude trends 1965-2015.

Source: <https://www.epa.gov/climate-indicators/climate-change-indicators-river-flooding>

² <https://www.epa.gov/climate-indicators/climate-change-indicators-river-flooding>

3 ONE-SIDED OVERSIMPLIFICATIONS IN SCIENCE SUMMARY CHAPTERS

Chapters 2 (Climate Trends) and 3 (Earth Systems Processes) form the scientific core of NCA5. As we will show in the following examples they fail to meet statutory requirements to discuss scientific uncertainties and the role of natural variability, and they fail to meet the more stringent implicit standards expected of a policymaking report.

3.1 Increased Lower Bound of Climate Sensitivity

The promotional tone of Chapter 1 is carried forward into Chapter 3 (Earth System Processes) where, on page 3-10, Key Message 3.2 states “The Estimated Range of Climate Sensitivity Has Narrowed by 50%”. Referring to Equilibrium Climate Sensitivity (ECS) the section elaborates:

Recent improvements in the understanding of how climate feedbacks vary across timescales have narrowed the estimated *likely* range of warming expected from a doubling of atmospheric carbon dioxide by 50% to between 4.5°F and 7.2°F (*high confidence*).... This uncertainty reduction results from advances in combining observations and targeted modeling results from nearly independent lines of evidence, each of which generally agrees on the values of ECS. The lines of evidence include 1) observed present-day variations on monthly to interannual timescales from which cloud and other climate feedbacks are inferred; 2) observed temperature changes between the preindustrial period and present and associated relationships to ERF; and 3) estimated temperature and radiative forcing changes for multiple warm and cold periods in paleoclimate records.

The graphic summary on page 3-11 states

The reduced uncertainty in climate sensitivity and climate feedback has been achieved through unprecedented quantitative synthesis of evidence from observed changes over recent decades, the industrial era, and paleoclimate.

This is a very inadequate description of the situation. The key development in AR6 was a *reduction* of confidence in the ability of climate models to identify ECS and the shift away from the model-based method the IPCC had relied on since AR1 in 1990. The IPCC instead turned to data-driven ECS estimation and specifically chose a single paper from the scientific literature, Sherwood *et al.* (2020³) for the purpose. It combined paleoclimate data, modern instrumental data and modern observations of climate processes, mainly cloud-related, that govern key feedbacks. Sherwood *et al.* used a subjective Bayesian method to determine the likely range of ECS values. The Bayesian approach begins with the researcher specifying a “prior”, namely an expectation of what the answer will be before seeing the data. In this case the prior consists of an expected ECS range based on the researchers’ subjective beliefs. Then the data are allowed to influence the ECS distribution and the final result is a weighted average of the assumed prior and the data-driven result. Sherwood *et al.* found a best (or median) ECS estimate of 5°F (3°C), which was close to previous model-based

³ Sherwood, S. C., Bony, S., Boucher, O., Bretherton, C. S., Forster, P. M., Gregory, J. M., & Stevens, B. (2020). An assessment of Earth’s climate sensitivity using multiple lines of evidence. *Reviews of Geophysics*, 58(4). <https://doi.org/10.1029/2019rg000678>

estimates but raised the likely lower bound by 1.7°F from 2.5°F to 4.2°F. The IPCC accepted this result and increased the best estimate to 3.1°C.

The NCA5 was published in November 2023. Well before that, in September 2022, Lewis (2023) had been published online at *Climate Dynamics* presenting a forceful critique of Sherwood *et al.*⁴ One of Lewis' points was that Sherwood *et al.*'s result was dependent on their chosen subjective prior. Lewis recommended using an objective Bayesian method, which places primary weight on the data rather than the researcher's expectation. Using that and updated forcing data from AR6, Lewis estimated an ECS best estimate of 3.7°F (2.2°C) with a likely lower bound of 2.7°F (1.6°C).

Hence, in contrast to the promotional language of Chapter 3 a more valid summary of the ECS literature as it stood at the time of writing the NCA5 would be what we wrote in CWG25 (emphasis added):

For the AR6, the IPCC placed primary weight on the results of Sherwood *et al.* (2020) that combined historical and paleoclimate proxies with the process-based approach and yielded a best estimate of 3.1°C with a *likely* range of 2.6-3.9°C. Lewis (2022) raised a number of concerns about this result, including methodological errors, outdated input values, and use of subjective versus objective Bayesian priors in the analysis. Lewis' analysis found that climate sensitivity is estimated to be much lower and better constrained than in the Sherwood *et al.* analysis – median 2.2°C (1.8–2.7°C in the 17–83 percent *likely* range, and 1.6–3.2°C in the 5–95 percent *very likely* range). **The IPCC AR6 estimated only a 5 percent probability that ECS was below 2.3°C, whereas Lewis estimated it to be over 50 percent.** The most recent publications on the debate between Sherwood *et al.* and Lewis further defend their respective positions: Sherwood and Foster (2024) and Lewis (2025).

3.2 Presenting New Emission Scenarios as a Scientific “Advance”

Chapter 3 pp. 13-14 treats the release of new emission scenarios as a scientific “advance” without addressing the failure of many previous scenarios to match reality or providing an honest assessment of the likelihood that the new ones are biased in the same way.

Key Message 3.3 states “New Data and Analysis Methods Have Advanced Climate Science” and includes the following:

New scenarios of socioeconomic development, and their associated emissions and land-use changes, drive updated climate projections from Earth system models. The Scenario Model Intercomparison Project (ScenarioMIP) organized the main set of 21st-century projection experiments under the latest phase of the Coupled Model Intercomparison Project, CMIP6. These CMIP6 projections used newly developed scenarios based on Shared Socioeconomic Pathways (SSPs; Figure 3.4). Five SSPs represent alternative plausible trajectories of 21st-century GDP and population growth and the pace and pervasiveness of socioeconomic and technological progress within individual nations and across the world (see Table 3 in the Guide to the Report). SSP-specific drivers are used in integrated assessment models (IAMs)

⁴ Lewis, N. (2023). Objectively combining climate sensitivity evidence. *Climate Dynamics*, 61(9–10), 3155–3163. <https://doi.org/10.1007/s00382-022-06398-8>. The final citation for this paper is Lewis (2023) because the print edition did not appear until 2023, but the article was accepted in August 2022 and the online edition appeared and was in circulation in September 2022.

to simulate the corresponding evolution of the energy system and the resulting greenhouse gas trajectories. These are in turn used by ESMs to drive their 21st-century projections.

There is nothing wrong with NCA5 discussing the development of new emission scenarios which serve as inputs to climate change projections and impact studies. But it is a serious omission not to inform the reader of the failure of many previous IPCC scenarios to match reality and the tendency of the scenario groups to exaggerate near-term and long-term CO₂ concentration growth (CWG25 3.2.1). It is also a serious omission not to caution readers that many climate impact studies use RCP8.5 which by the time of NCA5 had already been heavily criticized in the literature.

The same section also reports the availability of new and larger model ensembles as a scientific advance, without addressing ways in which models are getting worse in some key respects (CWG Ch 5).

3.3 Uncritical Promotion of “Emergent Constraints”

Chapter 3 page 17 presents the topic of “emergent constraints” in uncritical terms:

An approach to reduce uncertainty in climate change projections has matured over the past decade. It is known as “emergent constraints.” The term refers to strong statistical relationships between highly uncertain future climate parameters and observable trends or variations in the current climate, along with a physical explanation of this relationship.

Emergent constraints appeared in the climate modeling literature as a way to tie GCM behavior to climate observations in hopes of generating insight into real-world ECS. Climate models exhibit a wide range of sensitivities. The idea of emergent constraints is to examine whether the models with shared sensitivity values also share a common representation of some climate process (usually related to clouds) that might indirectly influence ECS. Suppose, for instance, that in low-ECS models the total cloud fraction in the tropics is strongly correlated with that in the southern midlatitudes but in high-ECS models the correlation is weak. Then researchers could check if the observed correlation is strong or weak and draw a conclusion about which type of model, and therefore which ECS value, is more likely.

A problem in the emergent constraint literature is that there has been a large proliferation of proposed correlations with little physical motivation. Many emergent constraints patterned on CMIP5 models failed to work on CMIP6 models (Schlund *et al.* 2020)⁵. In other words, the observed correlations in CMIP5 models between ECS and cloud processes failed to show up in CMIP6 models, indicating that they were likely spurious rather than clues to physical processes governing the Earth climate system. The result was that emergent constraints estimated on CMIP5 models widened the range of estimated ECS values when applied to CMIP6 models.

Schlund *et al.* summarized the problem as follows:

In this study, we systematically analyze 11 published emergent constraints on ECS that have mostly been derived from models participating in the Coupled Model Intercomparison Project Phase 5 (CMIP5) project... The focus of the study is on testing if these emergent

⁵ Schlund, Manuel, Axel Lauer, Pierre Gentine, Steven C. Sherwood, and Veronika Eyring (2020) Emergent constraints on equilibrium climate sensitivity in CMIP5: do they hold for CMIP6? *Earth System Dynamics* 11 1233-1258 <https://doi.org/10.5194/esd-11-1233-2020>

constraints hold for [Earth System Models] participating in the new Phase 6 (CMIP6). Since none of the emergent constraints considered here have been derived using the CMIP6 ensemble, CMIP6 can be used for cross-checking of the emergent constraints on a new model ensemble. **The application of the emergent constraints to CMIP6 data shows a decrease in skill and statistical significance of the emergent relationship for nearly all constraints, with this decrease being large in many cases.** Consequently, the size of the constrained ECS ranges (66% confidence intervals) widens by 51% on average in CMIP6 compared to CMIP5.

Yet NCA5 described the use of emergent constraint analysis as a great “advance” that reduced uncertainty.

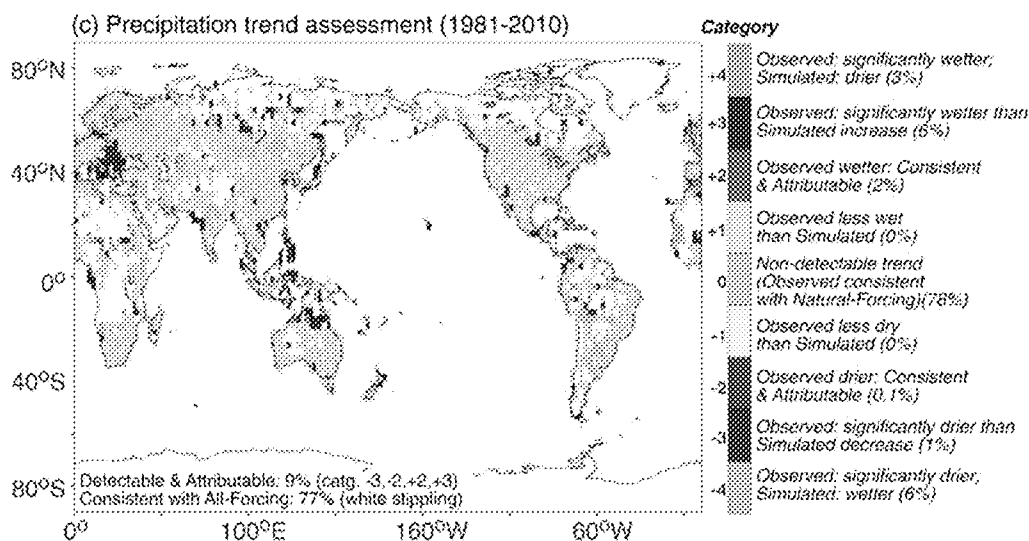
3.4 Overstating Findings in Underlying Sources

Although we did not do a detailed audit of the NCA5’s use of source material, a few spot checks turned up evidence of a pattern of overstatement.

Chapter 2 page 11 reports on an increase in precipitation in central and eastern US based on a comparison of 2002-2021 average rainfall to the average over 1901-1960. Note that this a non-standard metric; we will discuss NCA5’s inconsistent choices of time scales of analysis below. The change in this case is called a “trend” even though this is not how a trend is measured, and says that it is “attributable to climate change”. The claims were attributed to the following paper:

- Knutson, Thomas and Fanrong Zeng (2018) “Model Assessment of Observed Precipitation Trends over Land Regions: Detectable Human Influences and Possible Low Bias in Model Trends” *Journal of Climate* 31(12)
<https://journals.ametsoc.org/view/journals/clim/31/12/jcli-d-17-0672.1.xml>

But Knutson and Zeng did not say these things. It examined linear trends over 1901 – 2010, 1951 – 2010 and 1981 – 2010. It did not compare average rainfall over 2002 - 2021 to average rainfall over 1901 – 1960, indeed it was published in 2018 so it could not have. With regard to 1981-2010 trends its results were summarized in the following figure:



Gray indicates no trends detected. Stippling means that there were no trends in the models either so the models and observations agreed in that respect. Detectable and attributable trends were found over only 9% of the land surface of the Earth. Over the US there are detectable trends over only a few regions in the Southwest.

Chapter 2 page 18 states

There is robust evidence that human-caused warming has contributed to increases in the frequency and severity of the heaviest precipitation events across nearly 70% of the US.

This is attributed to two papers:

- Diffenbaugh, N.S., D. Singh, and J.S. Mankin, 2018: Unprecedented climate events: Historical changes, aspirational targets, and national commitments. *Science Advances*, **4** (2), 3354. <https://doi.org/10.1126/sciadv.aao3354>

and

- Kirchmeier-Young, M.C. and X. Zhang, 2020: Human influence has intensified extreme precipitation in North America. *Proceedings of the National Academy of Sciences of the United States of America*, **117** (24), 13308-13313. <https://doi.org/10.1073/pnas.1921628117>

Diffenbaugh et al. presented ratios of observed occurrences of extreme events to simulated occurrence rates in CMIP6 models run with only natural forcings. They report that for 79% of the U.S. extreme rainfall event frequencies are currently higher than in model simulations, and the ratio of occurrences will rise under future warming simulations. This is not “robust” evidence of anthropogenic influence since it requires readers to assume that climate models provide accurate simulations of regional precipitation patterns, something which even the IPCC AR6 admits is uncertain (AR6 WGI SPM Box SPM 1.2, SPM Section C.1.3).

Kirchmeier-Young and Zhang looked at extreme 1- and 5-day events in North America and, using 3 GCMs, found “A signal of combined anthropogenic and natural external forcing can be detected in the intensification of extreme precipitation at the continental scale over North America. In some cases, this intensification can be attributed to human influence specifically.” However, they noted large differences among the three models in their simulated precipitation changes. Also, 2 of the 3 models failed to yield detection for Rx5Day for the North America mean. Finally, the authors used Total Least Squares, an estimation method known to overstate signal detection results (CWG Section 8.3.2) . Here again this is not “robust” evidence, it is suggestive but other studies have found natural variability predominant.

4 RELIANCE ON *Ad Hoc* TIME SCALES FOR TREND ANALYSIS

In CWG25 Chapter 6 we discussed the need to be careful regarding the choice of time scale when making claims about trends in extreme weather. We gave examples from analysis of river flooding (6.1), heatwaves (6.3) and extreme precipitation (6.4) to show how assertions about apparent trends based on short data sets fall apart when looking at longer versions of the same data sets. Here we elaborate on these examples to illustrate a general point that NCA5 made inconsistent and *ad hoc* choices about time scales of analysis, weakening the validity of their conclusions.

4.1 Average and Extreme Precipitation

McKittrick and Christy (2019)⁶ showed that apparently significant positive trends in U.S. average and extreme precipitation over the NCA4 interval (1901 – 2016) disappeared on longer samples (extending back as far as the 1840s depending on location or on a shorter interval coinciding with the final 40 years of the data then available (1978 – 2017).

In CWG Section 6.4 we presented analysis of updated data for the same locations and many more besides, in all cases finding considerable regional heterogeneity and lack of robustness of trends to use of long samples.

NCA5 did not continue the NCA4 precedent of using the post-1901 interval as the time scale for its precipitation discussion, instead it refers to changes “since the 1950s” which we take to mean 1950 onwards. For the present report we have extended the analysis even further now to include 141 stations across the US in the Pacific Coast, Southwest, Midwest, Northeast and Southeast regions. We provide details in the Appendix; here we note merely that once again it is possible to find trends that support the NCA5 position, but they are not robust to selecting longer or shorter time scales of analysis. Data from 1950 to 2024 yields many indications of increased average and extreme precipitation at individual stations and region-wide averages. But when using the entire data set (back to the 1890s or earlier depending on location) or the later subset (1980 to 2024) the trends become smaller, in many cases they become statistically insignificant, and occasionally they change sign. Only in the Northeast region are the post-1950 trends robust to focusing on the post-1980 interval.

Under Key Message 2.2 “Extreme Events Are Becoming More Frequent and Severe” (p. 2-16) NCA5 states (p. 2-18):

“Rainfall is becoming more extreme”

Since the 1950s, there has been an upward trend in heavy precipitation across the contiguous US. This increase is driven largely by more frequent precipitation extremes, with relatively smaller changes in their intensity. The largest increase in the number of extreme precipitation days (defined as the top 1% of heaviest precipitation events) has occurred over the Northeast (an increase of around 60%) and Midwest (around 45%), along with increases of more than 10% in their annual and 5-year maximum amount

⁶ McKittrick, R., and J.R. Christy (2019). Assessing changes in US regional precipitation on multiple time scales. *Journal of Hydrology*, 578, 124074. <https://doi.org/10.1016/j.jhydrol.2019.124074>

(Figure 2.8). These changes have contributed to increases in river and stream flooding in these regions. The increase in frequency and intensity of precipitation extremes is evident across a broad range of event durations (from 1 to 30 days) and return intervals (1 to 20 years), particularly east of the Rocky Mountains.

There is robust evidence that human-caused warming has contributed to increases in the frequency and severity of the heaviest precipitation events across nearly 70% of the US. Paleoclimate records derived from tree-ring growth provide evidence that summer moisture has increased over the past century in parts of New England, the central-eastern US, and the northern Mississippi River valley.

The following is a more accurate summary of what U.S. data show.

There are regionally-heterogeneous changes in average and extreme precipitation. Positive trends in annual average rainfall and extreme events (defined either as the annual maximum or the number of exceedances of the 99th percentile value) are generally weak or non-existent when looking at samples exceeding 130 years in length. Significant trends can be found when beginning the sample in the 1950s although in most cases the trends weaken and become insignificant when looking at the post-1980 interval. This makes attribution to anthropogenic warming difficult.

Along the Pacific coast very few stations (1 or 2 out of 29) exhibit significant trends on any time scale in any metric and the region-wide trends are insignificant. In the Southeast region about 5 out of 24 stations exhibit positive trends in average and extreme precipitation metrics and the regional trends are likewise significant, but only on samples beginning in 1950. When the sample starts in 1873 or 1980 the trends weaken and become mostly insignificant. In the Midwest region nearly half the stations exhibit positive and significant trends in average precipitation since 1893 (23/61) and 1950 (28/61) but the trends weaken after 1980: only 6/61 locations are significant and the region-wide trend is insignificant. Regional trends in max and 99th percentile exceedances are insignificant post-1893 and -1980 but the latter are positive and significant post-1950.

In the Northeast region 12 out of 27 stations exhibit positive and significant increases in average precipitation post-1888, post-1950 and post-1980 (10/27) and the regional trend is positive and significant in all three intervals. The regional number of 99th percentile exceedances has a positive trend post-1950 and post-1980 but not post-1888. The significant positive trends post-1980 are concentrated in NH but are insignificant elsewhere.

Consequently, precipitation in the U.S. exhibits considerable regional and temporal variability. Relatively more places became wetter than drier. In the Midwest and Northeast the general pattern since 1950 favors increased precipitation depending on the location, although trends since 1980 have not tended to be statistically significant.

4.2 Heatwaves

- details; NCA4 used entire 20th century while NCA5 looked at post-1960 interval

5 INADEQUATE TRACEABLE ACCOUNTS

- details

6 OVERCONFIDENCE WHEN STATING CONCLUSIONS

- details

7 RELIANCE ON EXTREME SCENARIOS

-details

8 BIASED SELECTION OF REFERENCES

-details

9 SUMMARY: EVALUATING OF THE NCA5

9.1 Pertinent aspects when evaluating in light of statutory requirements

- not our remit to make a ruling but here are aspects to consider in light of statutory requirements

9.2 Evaluation from the perspective of expert users of the report

- we have deep knowledge of the topics surveyed by the NCA5 authors
- we do not have confidence that the report was balanced and comprehensive
- we can point to many specific instances in which the report did not exhibit an appropriate level of quality or integrity as a scientific document
- we have reason to believe the whole process, from author selection to handling of expert reviews, was biased towards reinforcing foregone conclusions and alarmist messaging

9.3 Evaluation from the perspective of citizens interested in good policymaking

- Public concerns about climate change are valid, as are concerns about cost of living, economic growth, employment, etc.
- We share the general concern that elected officials and those who serve them have the best information available when making important decisions around energy and climate policy
- NCA5 was a missed opportunity: it could have been a valuable input to that process but it did not turn out that way
- consequently its usage is unlikely to lead to better decisions and would more likely increase the error rate in policy formation and we recommend it not be used for policymaking purposes.

APPENDIX 1: Seth's letter on statutory requirements for NCA5

APPENDIX 2: Analysis of 141 U.S. Longterm Daily Precipitation Records.

Table codes: (-) neg insignificant, -- neg significant, (+) pos insignificant, ++ pos significant.

Column 1: Measure

Column 2: Number of stations in that region

Column 3: Count of stations exhibiting a significant positive trend

Column 3: Count of stations exhibiting a significant negative trend

Column 5: Characteristic of region-wide trend

PACIFIC COAST

Since 1893:

	No. stns	+ trends	- trends	region
1-day average	29	0	1	(-)
2-day average	29	0	1	(-)
Avg on non-zero days	29	0	9	--
Variability	29	1	0	(+)
Annual max	29	2	1	(+)
Number of 99 th pct exceedances	29	1	0	(-)

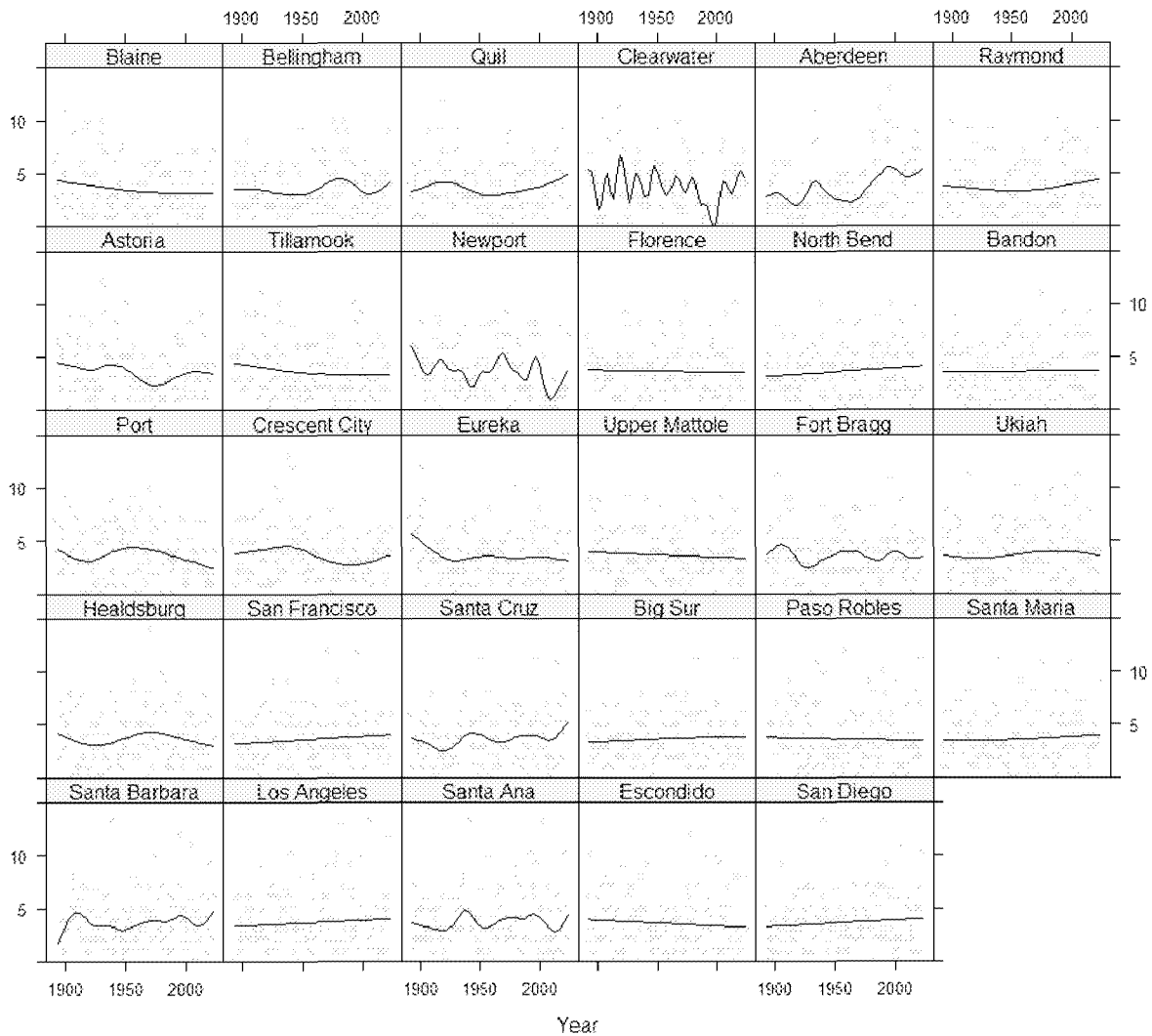
Since 1950:

	No. stns	+ trends	- trends	region
1-day average	29	0	1	(-)
2-day average	29	0	1	(-)
Avg on non-zero days	29	0	4	(-)
Variability	29	2	3	(-)
Annual max	29	6	3	(-)
Number of 99 th pct exceedances	29	2	1	(-)

Since 1980:

	No. stns	+ trends	- trends	region
1-day average	29	0	0	(-)
2-day average	29	0	0	(-)
Avg on non-zero days	29	0	1	(-)
Variability	29	0	0	(-)
Annual max	29	2	1	(-)
Number of 99 th pct exceedances	29	0	0	(+)

Annual No. 99th Percentile Exceedances PC 1893-2024



SOUTHEAST

Since 1873:

	No. stns	+ trends	- trends	region
1-day average	24	1	1	(+)
2-day average	24	1	1	(+)
Avg on non-zero days	24	7	2	(+)
Variability	24	1	0	(+)
Annual max	24	2	0	(+)
Number of 99 th pct exceedances	24	5	0	(+)

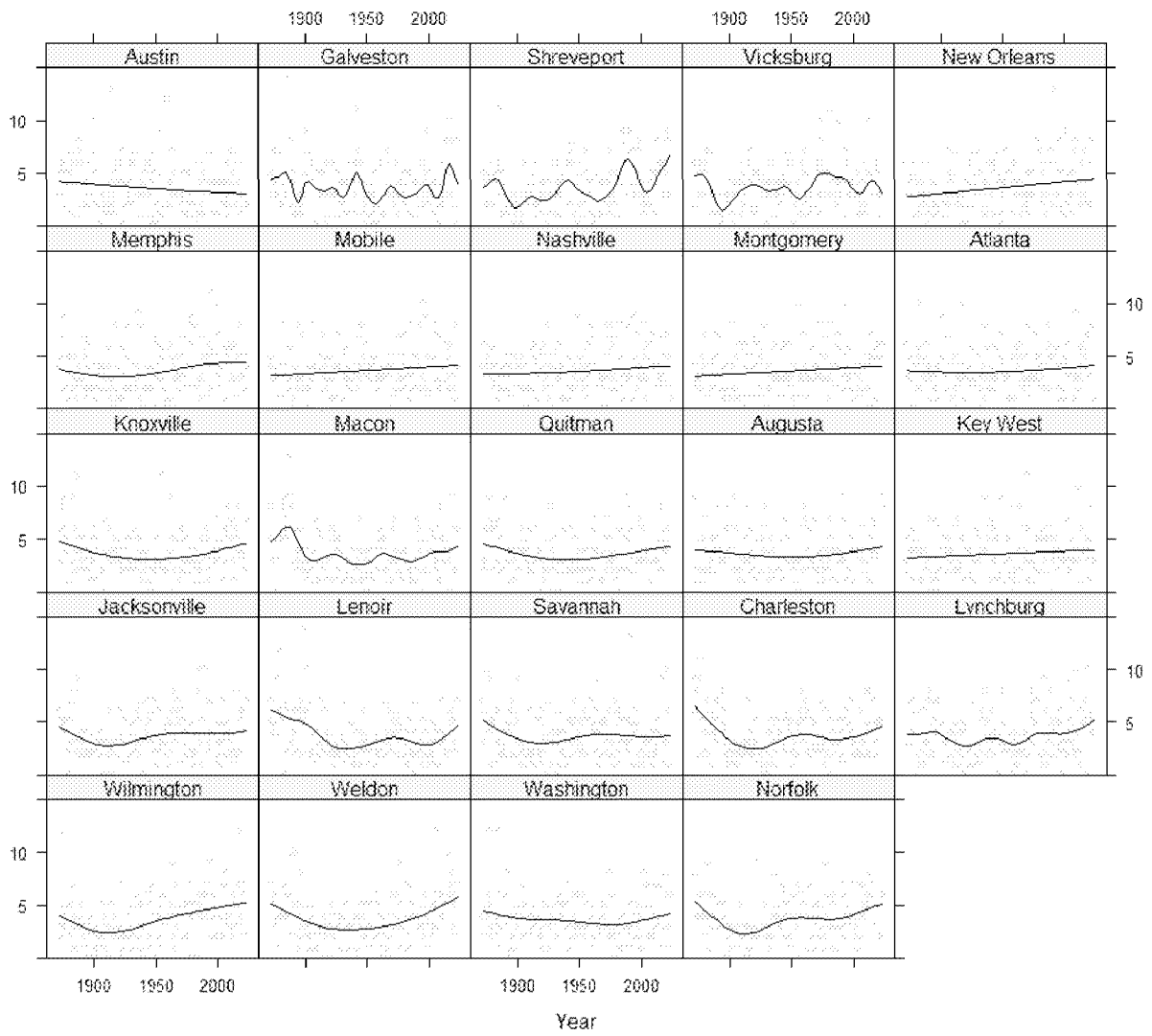
Since 1950:

	No. stns	+ trends	- trends	region
1-day average	24	5	0	++
2-day average	24	5	0	++
Avg on non-zero days	24	5	1	++
Variability	24	6	0	++
Annual max	24	4	0	++
Number of 99 th pct exceedances	24	4	0	(+)

Since 1980:

	No. stns	+ trends	- trends	region
1-day average	24	5	0	(+)
2-day average	24	5	0	(+)
Avg on non-zero days	24	5	1	(+)
Variability	24	3	0	(+)
Annual max	24	4	0	(+)
Number of 99 th pct exceedances	24	4	0	(+)

Annual No. 99th Percentile Exceedances SE 1873-2024



MIDWEST

Since 1893:

	No. stns	+ trends	- trends	region
1-day average	61	23	0	++
2-day average	61	23	0	++
Avg on non-zero days	61	2	12	(+)
Variability	61	12	0	++
Annual max	61	9	0	(+)
Number of 99 th pct exceedances	61	10	0	(+)

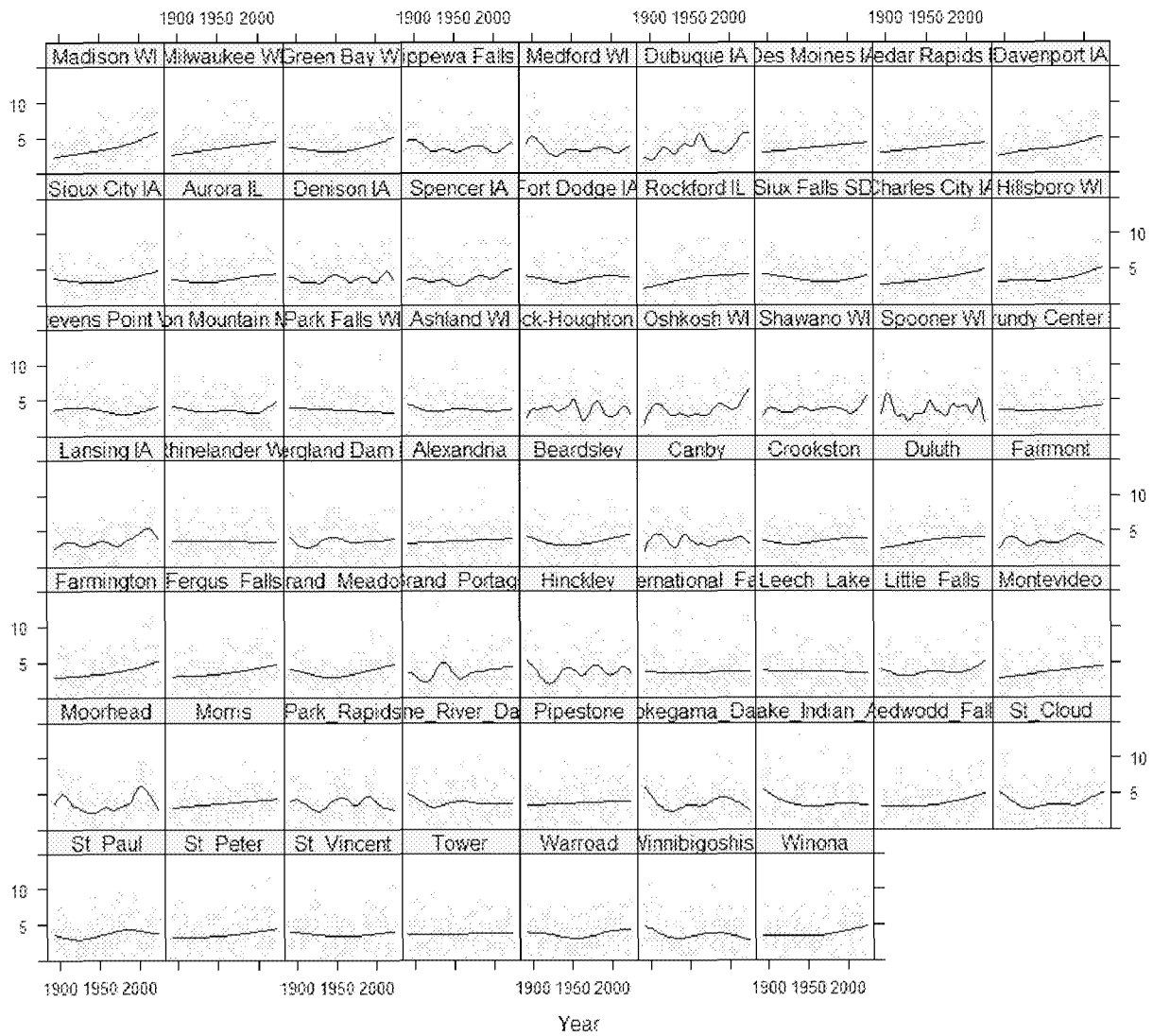
Since 1950:

	No. stns	+ trends	- trends	region
1-day average	61	28	2	++
2-day average	61	28	2	++
Avg on non-zero days	61	11	1	++
Variability	61	16	0	(+)
Annual max	61	8	0	(+)
Number of 99 th pct exceedances	61	19	0	++

Since 1980:

	No. stns	+ trends	- trends	region
1-day average	61	6	1	(+)
2-day average	61	6	1	(+)
Avg on non-zero days	61	8	2	(+)
Variability	61	5	1	(+)
Annual max	61	0	1	(+)
Number of 99 th pct exceedances	61	5	3	(-)

Annual No. 99th Percentile Exceedances MW 1893-2024



NORTHEAST

Since 1888:

	No. stns	+ trends	- trends	region
1-day average	27	12	0	++
2-day average	27	12	0	++
Avg on non-zero days	27	7	1	(+)
Variability	27	4	0	(+)
Annual max	27	3	0	(-)
Number of 99 th pct exceedances	27	5	0	(+)

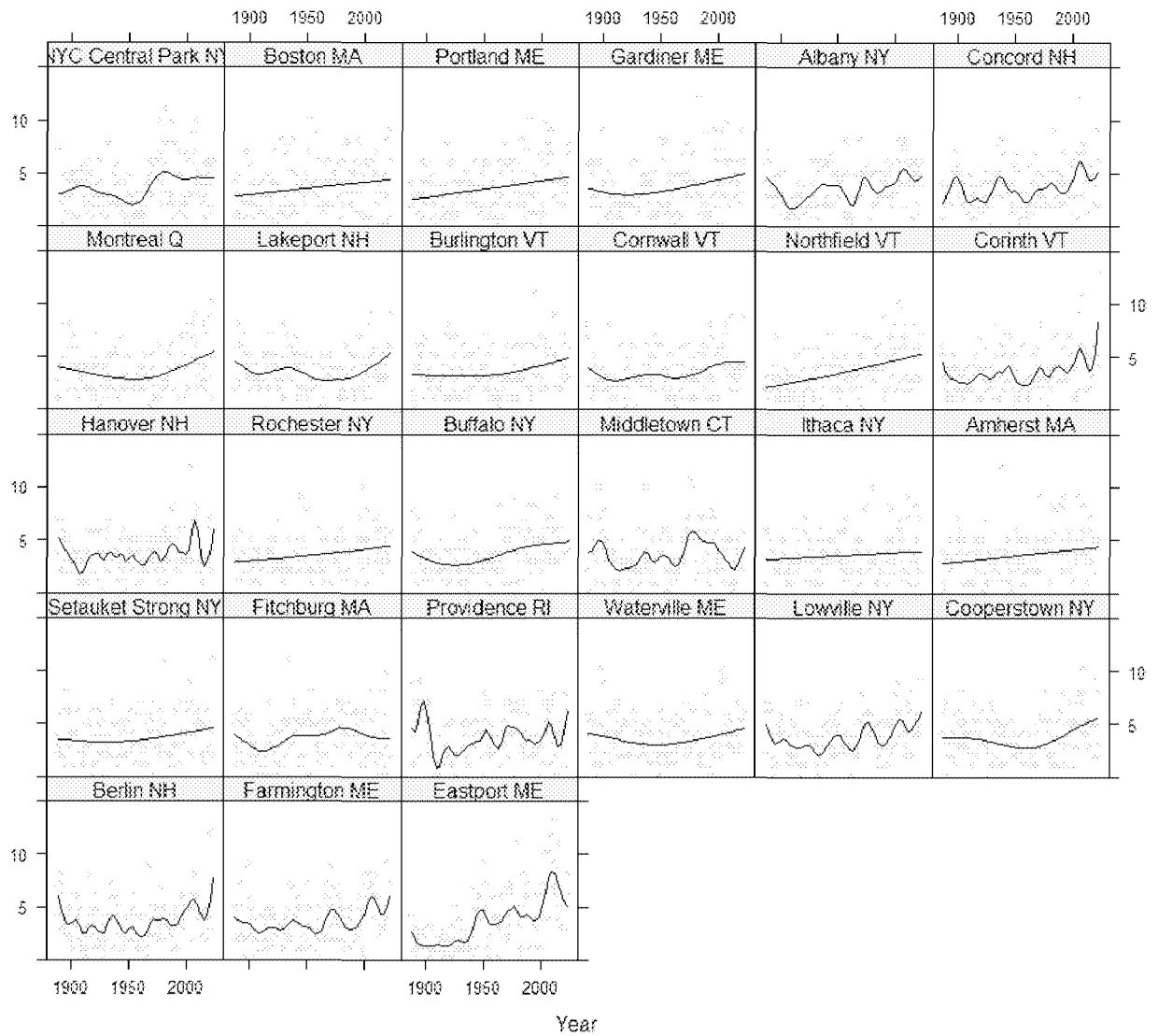
Since 1950:

	No. stns	+ trends	- trends	region
1-day average	27	12	0	++
2-day average	27	12	0	++
Avg on non-zero days	27	7	1	(+)
Variability	27	4	0	(+)
Annual max	27	3	0	(-)
Number of 99 th pct exceedances	27	5	0	++

Since 1980:

	No. stns	+ trends	- trends	region
1-day average	27	10	1	++
2-day average	27	10	1	++
Avg on non-zero days	27	6	0	(+)
Variability	27	2	0	(+)
Annual max	27	1	0	(+)
Number of 99 th pct exceedances	27	1	1	++

Annual No. 99th Percentile Exceedances NE 1888-2024



From: Judith Curry <curry.judith@gmail.com>
Sent: Thursday, August 14, 2025 7:32 PM
To: Dr. Ronan Connolly; Soon, Ph.D, Willie; Steve Koonin; John Christy; Roy Spencer; Ross McKittrick
Subject: Requesting your help with comments on the DOE report
Attachments: Connolly_soon.docx

Hello Ronan and Willie,

We've received the first round of comments on our DOE Climate Report from the Carbon Brief survey. A number of comments relate to solar, and your papers are heavily referenced in our report. I've attached a doc with the relevant comments we've received and the specific text referred to. We would appreciate any help that you can provide in responding to these comments, and whether any comments have merit and should result in some changes to our text.

Best regards,

The DOE Climate Working Group
John Christy
Judith Curry
Steve Koonin
Ross McKittrick
Roy Spencer

p.s. Ronan, congrats on your wedding, I hope that you and Alina are ecstatically happy. I also suspect that you might be on your honeymoon, in which case please ignore this for a few weeks!

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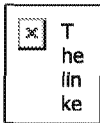
Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Judith Curry [curry.judith@gmail.com]
Sent: 8/5/2025 8:48:44 PM
To: Travis Fisher [travis.scott.fisher@gmail.com]; Josh Loucks [loucksj14@gmail.com]; Cohen, Seth [seth.cohen@hq.doe.gov]; Barrios, Audrey [audrey.barrios@hq.doe.gov]
CC: Ross McKittrick [ross.mckittrick@gmail.com]; Steven Koonin [steven.koonin@gmail.com]; Roy Spencer [roywspencer@hotmail.com]; John Christy [climateman60@gmail.com]
Subject: Response to the internal DOE reviews
Attachments: DOE review responses final.zip

The final responses to the internal DOE reviews are attached in a zip file

.....|

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Judith Curry, President
CFAN - Climate Forecast Applications Network
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<http://www.cfanclimate.net>

Pg	Para	Comment or Suggested Edit	
viii	2	The greening effect can't be due to increase in CO2 alone. The fertilization effect needs Nitrogen and phosphorous. There is observational[1] evidence that nitrogen available to plants is decreasing with increasing CO2 and thus acting to limit fertilization effect. Secondly, the greening of some portions of the planet are likely due to changes in precipitation patterns associated with changing climatic conditions and not entirely attributable to fertilization effect. We will also need to consider that the temperature effect on photosynthesis will also be a limiting mechanism to any continued greening due to fertilization in the future [2]. I recommend acknowledging that the greening is not attributable to CO2 alone and continued greening in the future with increasing CO2 is uncertain. Changed sentence to “Elevated concentrations of CO₂ directly enhance plant growth, globally contributing to “greening” the planet”	[1] Rachel E. Mason et al. Evidence, causes, and consequences of declining nitrogen availability in terrestrial ecosystems. Science 376, eabh3767(2022).DOI:10.1126/science.abh3767 [2] C.E. Moore, et al. The effect of increasing temperature on crop photosynthesis: from enzymes to ecosystems. Exp. Bot., 72 (8) (2021), pp. 2822-2844
viii	3	I am glad we acknowledge that CO2 causes warming, though I am not sure why we are not considering other energy sector related emissions that also cause warming (CFCs/HFCs, methane, aerosol effects). It is not clear what is meant by "CO2 emissions have tended to overestimate observed trends". This is not correct, the cumulative emissions track the RCP8.5 scenario the closest [3,4]. While there was a decrease in emissions during the Covid-19 period the emissions are now back on track following RCP8.5. This statement should clarify what is meant by the statement in the text. Rewrite sentence in the summary section to read “Climate change simulations require scenarios of distant future emissions. There is evidence that scenarios widely-used in the impacts literature have overstated observed and likely future emission trends.” On page 16 text added “Schwalm et al. (2020) defended the use of RCP8.5 on the grounds that cumulative CO2 emissions over 2005-2020 track it more closely than the lower RCP scenarios. They also argue that a modified version of the IEA scenarios closely track RCP8.5 in the coming decades. Hausfather and Peters (2020b) responded that the skill of RCP8.5 over those 15 years is due to offsetting errors in its representation of CO2 from fuel use and land use change, and the apparent agreement with IEA in coming decades is due to Schwalm et al. adding in very high land use emissions. The IEA’s own projected CO2 emissions track well below RCP8.5.”	[3] C.R. Schwalm, S. Glendon, & P.B. Duffy, RCP8.5 tracks cumulative CO2 emissions, Proc. Natl. Acad. Sci. U.S.A. 117 (33) 19656-19657, https://doi.org/10.1073/pnas.2007117117 (2020). [4] C.R. Schwalm, S. Glendon, & P.B. Duffy, Reply to Hausfather and Peters: RCP8.5 is neither problematic nor misleading, Proc. Natl. Acad. Sci. U.S.A. 117 (45) 27793-27794, https://doi.org/10.1073/pnas.2018008117 (2020).

viii	4	This paragraph seems to be talking about equilibrium climate sensitivity. The most recent model inter-comparison gives a wider range of climate sensitivities in the range of 1.8 to 5.7 and is wider than estimates of climate sensitivities that have been estimated from paleoclimatic and more recent historical datasets, in the range could be in the range of 2.3 to 4.5 K[5]. The higher sensitivity in the most recent model assessments are an area of active investigation by modelers, the feasibility of a higher range needs to be confirmed with additional observational and process scale modeling [6]. The range for climate sensitivities, 1.8-2.7, should be corrected to the most recent findings, 2.3-4.5. We should also recognize that the (a)earth is a complex system of systems (b)we can't do an experiment to find out what is correct or reduced the uncertainty. As we get better at extracting temperature records and CO2 concentrations from paelo data, there will be better reconstructions and possibly narrower range along with improvements in modeling that resolve many physical, biological and chemical processes as we get to higher and cloud resolving spatial resolutions. We discuss Sherwood et al. in Ch 4. Sentence changed: “Data-driven methods yield a lower and narrower range.”	[5] Sherwood, S. C., Webb, M. J., Annan, J. D., Armour, K. C., Forster, P. M., Hargreaves, J. C., et al. (2020). An assessment of Earth's climate sensitivity using multiple lines of evidence. <i>Reviews of Geophysics</i>, 58, e2019RG000678. https://doi.org/10.1029/2019RG000678 [6] Zelinka, M. D., Myers, T. A., McCoy, D. T., Po-Chedley, S., Caldwell, P. M., Ceppi, P., et al. (2020). Causes of higher climate sensitivity in CMIP6 models. <i>Geophysical Research Letters</i>, 47, e2019GL085782. https://doi.org/10.1029/2019GL085782
viii	5	This is again not true for the majority of the models in the AR6. Figure 7.19 in the IPCC AR6 report shows that majority of the models exhibit a range within the observational range. The models running hot in the most recent decades are the ones with climate sensitivities grate than 5K, which are 3 out of a total of 40 and it should be noted that about the same number of models also are running cold' compared to observed[7] Paragraph has been rewritten: The world’s several dozen global climate models offer little guidance on how much the climate responds to elevated CO , with the average surface warming under a doubling of the CO concentration ranging from 1.8°C to 5.7°C [Section 4.2]. Data-driven methods yield a lower and narrower range [Section 4.3]. Global climate models generally run “hot” in their description of the climate of the past few decades–too much warming at the surface and too much amplification of warming in the lower- and mid- troposphere [Sections 5.2-5.4]. The combination of overly sensitive models and implausible extreme scenarios for future emissions yields exaggerated projections of future warming.	[7]Hausfather, Z., Drake, H. F., Abbott, T., & Schmidt, G. A. (2020). Evaluating the performance of past climate model projections. <i>Geophysical Research Letters</i>, 47, e2019GL085378. https://doi.org/10.1029/2019GL085378
viii	5,6,7	There is very little dispute that these are challenging issues for climate science. Many of the issues identified here related to compound effects (subsidence and se-level rise; wildfire and forest management) that requires further scientific investigation. Identifying further research avenues/focus areas will be helpful to firm up some of the challenges faced in using the climate projections as discussed in the paragraph 9. There is no disagreement here.	

viii	9	The focus on uncertainty is relevant and should be emphasized in future research. However, as a reasonable policy pathways, making decisions in the face of these uncertainties is critical. Most of the climate uncertainties that we have confidence at this time can be considered Level 2 and Level 3 uncertainties, approaches such as scenario analysis (and others) are suggested and followed for making hazard and risk estimates for future conditions. For deep uncertainty hazards (for example tornadoes etc.) that we don't have enough data or capability to model, developing methods for assessing the uncertainty and risk should be a focus of future research. There is no disagreement here. See Curry's book Climate Uncertainty and Risk.	
2	3	The reason CO2 was identified as a pollutant is the health consequences of increased temperature, flooding and other climate impacts and not because of any direct affect on health dur to exposure to atmospheric CO2[8]. There is no disagreement here.	[8] https://www.cdc.gov/climate-health/php/effects/index.html
3	1/C hap ter su m ma ry	The summary should note that CO2 fertilization effects are limited by the availability of other critical plant nutrients (Nitrogen, Phosphorous). The fertilization effect is also constrained by higher temperature effecting photosynthesis[9] Added sentence: Other contributing factors included warming and increased nitrogen.	[9] Xinyuan Wei et al 2025 Environ. Res. Lett. 20 064013
3	3	The attribution of greening to primarily CO2 fertilization is questionable as per recent research. Specifically, in the Northern high latitudes (where the greening is most prominent), increases in temperatures due to climate change has been shown to provide the best explanation[10]. In the sub-Saharan region reforestation efforts and changing precipitation patterns lead to some of the observed greening (the great green wall) [11]. The attribution to CO2 fertilization should be qualified by noting the other present and emerging constraints. We cite Zhu et al attributing 70% of change to CO2 . That implies other factors matter as well.	[10]Liu, J., Wennberg, P.O. An emergent constraint on the thermal sensitivity of photosynthesis and greenness in the high latitude northern forests. Sci Rep 14, 6189 (2024). https://doi.org/10.1038/s41598-024-56362-1 [11] Francesco S.R. Pausata, Marco Gaetani, Gabriele Missouri, Alexis Berg, Danielle Maia de Souza, Rowan F. Sage, Peter B. deMenocal, The Greening of the Sahara: Past Changes and Future Implications, One Earth, Volume 2, Issue 3, 2020, Pages 235-250, ISSN 2590-3322, https://doi.org/10.1016/j.oneear.2020.03.002 .
3	5	This summarization ignores the compound effects of temperature, moisture and CO2 fertilization in assessing the impacts of CO2 increase on vegetation and crop yields. Many studies have shown that [12]. Making note of these compensating factors is required for a balanced view on CO2 fertilization effects on plants. This issue is addressed in Chapter 9	[12]Lesk, C., Anderson, W., Rigden, A. et al. Compound heat and moisture extreme impacts on global crop yields under climate change. Nat Rev Earth Environ 3, 872–889 (2022). https://doi.org/10.1038/s43017-022-00368-8

4	1	Chen et al. (2024)[13] conclude that "In the attribution analysis of LAI trend and growth rate trend, there were some differences between multiple linear regression model and partial correlation analysis at high latitudes in the northern hemisphere. Partial correlation analysis showed that LAI trend and growth rate trend in this region were mainly affected by temperature and radiation, while multiple linear regression suggested that CO2 was the dominant driver. The results of the partial correlation analysis seem more reasonable because some previous studies have shown that vegetation change in the high latitudes of the northern Hemisphere is mainly positively affected by climate warming. Multiple linear regression model performed relatively poorly in this region and might not fully identify the contribution of individual drivers. In addition, our model does not include the contribution of land management, which has been highlighted in some previous studies. Of course, the contribution of land management to LAI trend and growth rate trend may be implied in other drivers, such as the positive contribution of CO2 to LAI trend in PP and PN areas". We have added the Chen references. Our existing summary doesn't conflict with this. They conclude CO2 is the dominant driver globally but not the only driver.	[13]Xin Chen, Tiexi Chen, Bin He, Shuci Liu, Shengjie Zhou, Tingting Shi, The global greening continues despite increased drought stress since 2000, <i>Global Ecology and Conservation</i>, Volume 49, 2024, e02791,ISSN 2351-9894,
6	1	This again suffers from not acknowledging the effects of compound and often compensating phenomena that is occurring with the on-going climate change. For example [14] note that much of the Midwest any benefit from CO2 fertilization will be negated by temperature increases. [15] note that "Our results show that long-term physiological acclimation dampens the initial stimulation of plant net carbon assimilation to elevated [CO2], and of plant water use to warming." The topic of agricultural productivity is addressed in Chapter 9 It is not disputed that effects of dT go negative at high enough levels. The 2013 paper by Ruiz-Vera et al doesn't provide much general information beyond the FACE experiment site. The C14 data set used is a global sample and takes both dT and dC into account.	[14]Ursula M. Ruiz-Vera, Matthew Siebers, Sharon B. Gray, David W. Drag, David M. Rosenthal, Bruce A. Kimball, Donald R. Ort, Carl J. Bernacchi, Global Warming Can Negate the Expected CO2 Stimulation in Photosynthesis and Productivity for Soybean Grown in the Midwestern United States , <i>Plant Physiology</i>, Volume 162, Issue 1, May 2013, Pages 410–423, https://doi.org/10.1104/pp.112.211938 [15] Lamba S, Hall M, Råntfors M, et al. Physiological acclimation dampens initial effects of elevated temperature and atmospheric CO2 concentration in mature boreal Norway spruce. <i>Plant Cell Environ.</i> 2018; 41: 300–313. https://doi.org/10.1111/pce.13079
8	1	The fallacy of these arguments in terms of PH changes and evolution is that the changes described in this paragraph occurred over millennia and the evolutionary process had time to adapt; here with climate change we are talking about changes in our lifetime, the speed of change is the issue. This will lead to collapse of some ecosystem and by the time adaptation takes place it will be millions of years and in a different climate - not the one we have now and that enabled the rise of humans. The chapter notes large regional and even diurnal variations in ocean pH. We already address the issue of short timescale variations on p. 8: "On the time scale of thousands of years, boron isotope proxy measurements show that ocean pH was around 7.4 or 7.5 during the last glaciation (up to about 20,000 years ago) increasing to present-day values as the world warmed during deglaciation (Rae <i>et al.</i>, 2018). Thus, ocean biota appear to be resilient to natural long-term changes in ocean pH since marine organisms were exposed to wide ranges in pH."	

5	Fig 2.2	A simple calculation will show us how misleading this figure is. It shows that over 600 Million years CO2 changed by around 6000ppm. That is a rate of change of 0.00001/yr; COE changed from 275 to 430 in the past 175 years, that is rate of change of 0.88ppm/yr. A change in the rate of over 10^5 in magnitude - there in lies the problem. We are seeing a rapid increase in CO2 that has never been witnessed and the ecosystem and huma society (which is at best 10K years old), may not be able to adapt to this rapid change. This figure has been deleted. We don't know what the rate of changes was on an annual or centennial time scale since the data are too low resolution. We have added the following sentence "While the modern rate of change in CO2 is likely high compared to prior intervals, the geological evidence is that plants and animals evolved under much higher CO2 levels than at present."	
12	Summary	The misuse of RCP8.5 as business as usual is acknowledged. However, this was never intended to be a no-policy or business as usual scenario but as a high-end baseline scenario. When dealing with interaction of physical systems with socio-economic projections (which tend to be highly uncertain and policy dependent), the development of this high baseline scenarios is intended to explore the uncertainty ranges that represent a high-end scenario[16,17]. As any engineer would acknowledge, this is a prudent approach when dealing with L3 and L4 type deep uncertainties and provide valid envelopes for assessing uncertainties and risks from high impact events/hazards. The rest of the statements here are uncertainties acknowledged by the climate scientists and included in developing projections and discussing the results[4]. Does the IPCC downplay the role of sun in climate change? The IPCC includes sun variability in all its assessments from the beginning and has been acknowledged as a potential but insignificant contributor. The comments do not imply any disagreement with what we have written. Extreme scenarios for models are useful for bracketing outcomes but our criticism (based on the literature) is the widespread use of RCP as a no-policy baseline; the reviewer acknowledges that was never its purpose. The IPCC's assessment insignificance of the sun in climate change is based in part on use of low variability irradiance reconstructions that rule out it having any role. This is addressed in Chapter 8	[16]van Vuuren, D.P., Edmonds, J., Kainuma, M. et al. The representative concentration pathways: an overview. Climatic Change 109, 5 (2011). https://doi.org/10.1007/s10584-011-0148-z [17]Hausfather, Z. (2025). An assessment of current policy scenarios over the 21st century and the reduced plausibility of high-emissions pathways. Dialogues on Climate Change, 2(1), 26-32. https://doi.org/10.1177/29768659241304854 (Original work published 2025)
16	2,3, 4,5	Please see above. The business-as-usual may be a misnomer but this is an 95% case that is typically included in any type of prudent uncertainty analysis, in particular given the difficulty of predicting the evolution of socio-economic and political conditions over the next 100 years. It should be noted the difference between RCP8.5 and RCP4.5 for mid-century conditions that is of particular focus for adaptation studies in not significant and most of the divergence in these two scenarios occurs later in the century. Implausibility is not equivalent to very unlikely (e.g. 95th percentile), but rather includes impossible or implausible assumptions. High impact hazards occur independent of atmospheric CO2 concentrations (Chapter 6).	

19	5	That the dynamic vegetation models need more development is acknowledged and is a defining challenge for Earth System Modeling for the next decade. There is no disagreement here	
22	3	As noted, Parker[18,19,20] has investigated the Urban effects on temperature records. The finding establish that by comparing warm and wind conditions world wide that the impact is negligible. However, as noted by authors, this literature hasn't progressed much over the last decade and much more attention needs to be paid to this question by employing newer models, datasets and analytical techniques available to us at present. The CWG Report addresses this concern. We agree with the reviewer that the literature stalled a decade+ ago.	[18] Parker, D. Large-scale warming is not urban. <i>Nature</i> 432, 290 (2004). https://doi.org/10.1038/432290a [19]Parker, D.E. (2010), Urban heat island effects on estimates of observed climate change. <i>WIREs Clim Change</i>, 1: 123-133. https://doi.org/10.1002/wcc.21. [20]Parker, D. E., 2006: A Demonstration That Large-Scale Warming Is Not Urban. <i>J. Climate</i>, 19, 2882–2895, https://doi.org/10.1175/JCLI3730.1.
28	2	We can all agree that there is a desperate need for developing higher-resolution climate models that can get to cloud resolving scale so that we can represent the cloud feedbacks correctly in the model and avoid uncertainties from parameterization and scale dependency of the parameters. This doesn't make these models useless. The models provide directions for further improvements and necessary changes to reduce the uncertainty bands over the ECS. The climate models are useful for research purposes. The CWG Report demonstrates that they are not fit for the purpose of policy making. There's no guarantee increased resolution will be the answer, but if ever a model appears that can deal correctly with clouds that will be quite something. .	
29	2	The databased approaches have mostly been robust with changes at the high end around 3-4C and at the low end around 1.8 to 2.5C as noted in the chapter. It will be challenging to make this range shorter given the data requirements and uncertainties in data over paleo/haloocene periods. It seems reasonable to estimate that we may have ECS in the range of 3 to 4K (higher than 3.5K being less likely [21]) at the higher end and this should not prevent us from planning and thinking on ways to prevent this possible scenario as it could have major consequences for humans across the planet. The Report acknowledges that 4C is a reasonable upper bound for the likely range	[21] Michael Mann, <i>Our Fragile Moment: How lessons from Earth's past can help us survive climate crisis</i>, Hachette Group Inc., 2024.

32	3	The models range over a factor of three in ECS comparing the most sensitive to the least sensitive models. However vast majority of the models are in 3 to 3.5K sensitivity range and it is probably not correct to assign all models the same amount of importance, given the fact that some of institutes participating in the exercise have different levels of capacity to develop and test models. Only 5 of the models are between 3 and 3.5C Some of the most reputable models have the highest values of ECS, including UK and US models The point made in this paragraph is that research over several decades has not reduced the range of model ECS. For observers who rely on model outputs this is very concerning and again goes to the question of fitness for purpose, as posed in the prior paragraph.	
34	1	While this analysis for the CMIP6 model set is accurate and focuses on a dataset that has shown higher ECS than previous iterations. it should be noted the models have exhibited considerable skill in predicting the subsequent GMST warming[22]. The criticism of the CMIP6 based high ECS models may be premature and probably will have to wait additional time before passing judgement. As noted in [22] these models have shown considerable skill when evaluated on their projections over the past 30-40 years after the projections were published. <i>Figure 5.3 in the Report clearly refutes this assertion</i> Hausfather et al. did examine early model-obs matches but only using models that had relatively low ECS. The Scaffeta analysis covered a longer interval (1980-2021) than the Hausfather et al. analysis of SAR (1995-2017) and TAR (2001-2017). Its findings line up with Fig 5.3 and the tropospheric evidence in Fig 5.4.	[22]Hausfather, Z., Drake, H. F., Abbott, T., & Schmidt, G. A. (2020). Evaluating the performance of past climate model projections. <i>Geophysical Research Letters</i>, 47, e2019GL085378. https://doi.org/10.1029/2019GL085378
36	1	A recent study attributes the bias to inter-annual availability and residual bias in the satellite record. The pre- and post 2000 have temperature records from two separate satellites and the discrepancy in the trends needs to be resolved[23] Chung et al. (using output through 2014 only) confirm the models' too-high warming rates and suggested two issues that might contribute to at least part of the discrepancy: (1) the differential phasing of natural, ephemeral events such as El Niños between models and observations and (2) a possible spurious cooling in UAH and NOAA/STAR satellite datasets around 2000. Regarding (1) we agree that the timing of major events like ENSOs diminishes the fidelity of models-to-observations comparisons for short periods, but now with 46 years of record as well as two major El Niño warm events since 2014 in the observations, the results shown in Fig. 5.7 are quite appropriate for comparison. Regarding (2) Christy et al. 2018 (and later Zou et al 2023) specifically examined the divergence around 2000 between UAH and NOAA/STAR vs. RSS and UW demonstrating that RSS and UW's use of the aging and drifting NOAA-14 satellite relative to the new, highly calibrated NOAA-15 sensor contributed to a spurious warming in RSS and UW. Be that as it may, CWG Fig. 5.7 is clear in noting all models overestimate the tropical temperature trend relative to observations – model trends being even more positive than those of RSS and the two Reanalyses (in addition to UAH and NOAA/STAR).	[23]Chung, ES., Kim, SJ., Sohn, BJ. et al. Multi-decadal climate variability and satellite biases have amplified model-observation discrepancies in tropical troposphere warming estimates. <i>Commun Earth Environ</i> 5, 342 (2024). https://doi.org/10.1038/s43247-024-01510-8

38	3	This is challenge we need to face and work on improving the parametrizations. The new era of super high resolution models would resolve the complex interactions of turbulence, transport and clouds and will provide less uncertainty[24]. However, this can't be used to invalidate the entire set of models, the models are performing remarkably well given the complex system that is being modeled. It should be noted the models do cover the range of the observations and it is not outside the envelope of model predictions. The Report does not address invalidating the entire set of models. Rather we address the fitness-for-purpose of the models for policy making Fig 5.6 shows that to the extent there is a match with observations, it comes from models with very little CO2 response. “However, this can't be used to invalidate the entire set of models, the models are performing remarkably well given the complex system that is being modeled.” This statement is not supported by the evidence unless and until “remarkably well” is metricized for us to examine and make a determination. The paper cited doesn’t exactly apply to the real world (looking at Fig 1 doesn’t give one much confidence in models), but does give insight into the various models as best I can tell.	[24]Merlis, T. M., Guendelman, I., Cheng, K.-Y., Harris, L., Chen, Y.-T., Bretherton, C. S., et al. (2024). The vertical structure of tropical temperature change in global storm-resolving model simulations of climate change. Geophysical Research Letters, 51, e2024GL111549. https://doi.org/10.1029/2024GL111549
40	4	Part of the problem here may be which part of the stratosphere is sampled and the importance of interannual a variabilities in the lower part of the stratosphere. [25] have shown that including the stratosphere as defined from 25 to 50km there is high confidence that the cooling signal caused by CO2 increase is detectable and beyond the noise levels of the natural and inter annual variability in the lowest part of the stratosphere. We should put this debate to rest. Santer et al. (2023 has been added to the references with this text: Santer et al. (2023) use updated data to show that a cooling trend has not re-emerged in the lower stratosphere.	[25] B.D. Santer, S. Po-Chedley, L. Zhao, C. Zou, Q. Fu, S. Solomon, D.W.J. Thompson, C. Mears, & K.E. Taylor, Exceptional stratospheric contribution to human fingerprints on atmospheric temperature, Proc. Natl. Acad. Sci. U.S.A. 120 (20) e2300758120, https://doi.org/10.1073/pnas.2300758120 (2023).
42	2	Given the large uncertainties in obtaining data over much of the Northern Hemisphere, using a smaller regional analysis to discount the models may be inappropriate. We should that this remains a question we need to resolve developing better datasets with more seasonal and sub-seasonal coverage to test the model on a global scale The reviewer’s points are fine but it is important in the context of this report to point out discrepancies in the way models on some key continental-scale metrics such as, in this case, snow cover. This section directly addresses a region that is important to estimates of the Social Cost of Carbon in the context of agricultural productivity, again reiterating that the models are not fit for the purpose of policy making.	

44	3	This statement from [26] refers to the fitness of global scale models to resolve regional scale features and argues for developing model at higher spatial resolutions. Using downscaling and other techniques additional insights can be gained at regional scales and provide information for a set of 'purposes'. However, we should work on getting to regional and local scales with GCM as quickly as possible. The current model structural forms may not be adequate for resolving all of these issues merely by increasing spatial resolution. Simulating change at regional to local scales depends on getting the internal variability of the ocean correct, which is only partly a resolution issue.	
47	2	Looking for trends or estimating trends in extreme events in current and future climate is not necessarily an attribution study. Estimating frequency, duration and intensity of events helps understand the changing range of the hazard (if there is one). An attribution would be to find to what extent a particular event is influenced or affected by increase in CO2. I would consider these two not to be the same. We explain the distinction between detection and attribution	
47	3	Attributing any single event to changing climate is perilous, agreed. Yes. .	
47	5	As noted by [26] there is not yet any strong evidence that LPT is a fact We have eliminated mention of LPT explicitly, but retain elements of the text surrounding long term variability.	[26]Cohn, T. A., and H. F. Lins (2005), Nature's style: Naturally trendy, Geophysics. Res. Lett., 32, L23402, doi:10.1029/2005GL024476.
57	2	I am not sure how one can conclude that the temperature extremes have decreased based on figure 6.3.4. If I understand correctly the Tmax-Tmin for each year was tabulated and a mean of this difference averaged over the 100+ years was subtracted from these values to get some thing like a anomaly. This anomaly seems to have moved from +3F to -3F over the course of q00 years and now trending upwards again. This suggests to me that there has been significant changes in the extremes over the years and the most recent trend is towards warmer highs? Figure 6.3.3 clearly shows cold extremes have decreased on a centennial scale while warm extremes haven't changed much In Figure 6.3.4, for each station and each year, the hottest day and coldest night are determined and their difference computed. These differences are then geographically averaged for the CONUS and then an overall average is removed to show the results as a type of anomaly. Reviewer 1 is correct, as indicated in the text, Tmin temperatures are almost universally rising more rapidly than Tmax, hence, the difference (or range) has declined overall. A check of CMIP6 models for the CONUS under ssp4.5 shows half with TMax rising faster than Tmin and (obviously) half vice versa – so there is no clear signal from models that matches the observations. The flattening (or slight rise in the metric) in the past 20 years is clearly within the natural range, but does reveal an interesting stair-step pattern with rapid declines centered around the 1940's and 1990's and relatively flat periods in between. An explanation is under	

		investigation, and a leading hypothesis is that there was rapid growth of manufactured surfaces around weather stations in the 1940s. Then, in the 1960s-80s many stations were re-located to relatively rural airports, which then experienced subsequent growth in manufactured surfaces around their weather stations in the 1990s. Thus, rapid nighttime warming in the 1940s and 1990s.	
58	3	The NCA5 is suggesting that the western US is experiencing increase in extreme heat (page 57, para 4); it seems like figure 6.3.5 establishes the fact and not contradict. There was no claim of pervasive (all CONUS) increase in the report We have deleted the sentence “The NCA5 heading “The Risk of Temperature Extremes is Changing” suggests pervasive positive trends are now being observed in threshold temperatures, but that is not evident in the figures above.” It isn’t worth going into more detail in this report	
59	4	The definition of heat wave as consecutive 6 days seems to be a special case. The standard definition is exceedance of 85 or 90 percentile for 2 or more days. I can't check with NCA5 as it was taken down from the web As correctly suggested by Reviewer 1, there are numerous ways to define a heat wave. CWG chose to follow one definition discussed in NCA4 (pg 191) and use 6 consecutive days with Tmax > 90th percentile so as to allow for consistent comparisons. However, changing the parameters will do little to alter the fundamental result that the 1920's to early 1950's contain the major heat wave events for the CONUS.	
60	1,2	Figure 6.3.6 establishes that heatwaves as defined here have increased in the west and have shown increasing trend all over CONUS in the past 50 years. [27] shows the results for the last 60 years and there is little doubt that there is an increase over most of the CONUS, again the NCA5 report is off the web; figure 6.3.7 shows the heat waves are monotonically increasing from the 1960. Including the longer data is only interesting in the dust bowl 1930 camouflage the signal somewhat for the Midwest and central plains. The problem of taking averages over large regions (for example entire CONUS) is that it kills the peak signals and smooths out the emergent climate change indicators. Doing continental averages to look for extremes is really not very useful. Secondly, there is no particular reason to assume that the climate change signal (i.e. the number of heat waves) should showing up 100 years ago, as the CO2 in the atmosphere started to be of significance in the last 50 years. As discussed in the CWG text, the EPA chart is (1) based on nighttime temperatures in the 50 largest US cities and (2) begins in 1961 which was the start of the coolest decade in over 100 years, thereby preconditioning the chart to have an upward trend. Urbanization is most clearly seen in nighttime temperature increases so this does not represent a change in the background climate, but more likely the local climates of cities. Rural areas show less nighttime warming. And, avoiding earlier warm periods does not provide information on the larger scale of natural variability. We have added a sentence at the end of Section 6.3 “Irrespective of the ultimate cause of regional trends, heatwaves have important effects on society which must be addressed, as we discuss in Chapter 10. “	[27] https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves

61	4	averaged over all stations in the region, none of these trend parameters is statistically significant'. This is again how one would be looking at statistics of extremes in precipitation. As we know, precipitation is highly heterogenous and location dependent. As observed there are trends even with the approaches chosen by the authors of this study compared to NCA5 and averaging that over and saying there is no trend seems disingenuous. We summarize the site-specific trends as well as the regional average. The rationale for looking at the regional average is that a GHG signal should cover a wide area.	
62	2	same argument as above We summarize the site-specific trends as well as the regional average. The rationale for looking at the regional average is that a GHG signal should cover a wide area.	
63	box	again the issue here is that we are talking about events that are happening in a short-time and over a small region. Averaging over time and space and develop statistics is probably not appropriate when we are talking about events such as the recent flooding event in Texas. If you average that event over 30 days, it will seem unremarkable. Extreme event totals are 1-day to 5-day,s depending on section discussed. The point being made in the Box is that if you use a too-short record you may underestimate natural variability. I'm not sure how the reviewer's comment challenges this.	
64	1	As noted in NCA5 and shown in the analysis presented in figure 6.4.4 there is a clear trend of increase in extreme precipitation in 12 of the 27 stations analyzed. Again averaging over the entire region is not the best method for picking extreme precipitation events that are local both in time and space. We summarize the site-specific trends as well as the regional average. The rationale for looking at the regional average is that a GHG signal should cover a wide area. Also in this case we point out that the NE behaves differently than other regions.	

69	2	However, there is evidence that flash droughts, which last weeks have increased over the Northeast and Midwest [28] The paper referenced by Reviewer 1 begins with data so recent (1999) that it cannot provide evidence for long-term changes in drought as evidenced in the US Drought Monitor (DM) even though it suggests an increase in "flash droughts" over that period. Keep in mind, the DM is a product of subjective interpretation and objective measures - objective measures that have changed considerably during the past 25 years – thus is not metrically consistent. (One of the CWG authors was an official contributor to the DM for 15 years.) One would wonder what would the 1920's. 30's and early 50's reveal if the DM was operational back then? A more consistent metric is provided in CWG Fig. 6.7.1.	[28]Ronald D. Leeper, Rocky Bilotta, Bryan Petersen, Crystal J. Stiles, Richard Heim, Brian Fuchs, Olivier P. Prat, Michael Palecki, Steve Ansari
70	2	More recent analysis indicate forest loss due to wildfire accelerating over the recent past[29]. In particular there has been an increase in extreme fire radiative power with a 2 fold increase from 2003 to 2023 (period of satellite data availability)[30][31]. However, that these fires are not out-of-sample and there is a fire deficit as shown in figure 6.8.2 should be acknowledged. But this doesn't alleviate the concern that wildfire is leading to lot of socio-economic concerns and needs to be addressed[32] New sentence added: However there is evidence that the intensity of fires in some regions is worsening (Cunningham et al. 2024) and that wildfires resulted in a net loss of global forest cover over 2001-2019 (Tyukavina et al. 2022).	[29]Tyukavina Alexandra , Potapov Peter , Hansen Matthew C. , Pickens Amy H. , Stehman Stephen V. , Turubanova Svetlana , Parker Diana , Zalles Viviana , Lima André , Kommareddy Indrani , Song Xiao-Peng , Wang Lei , Harris Nancy; Global Trends of Forest Loss Due to Fire From 2001 to 2019, Frontiers in Remote Sensing.Volume 3 – 2022,2022. [30]Cunningham, C.X., Williamson, G.J. & Bowman, D.M.J.S. Increasing frequency and intensity of the most extreme wildfires on Earth. Nat Ecol Evol 8, 1420–1425 (2024). https://doi.org/10.1038/s41559-024-02452-2 [31]Patrick H. Freeborn, W. Matt Jolly, Mark A. Cochrane, Gareth Roberts, Large wildfire driven increases in nighttime fire activity observed across CONUS from 2003–2020, Remote Sensing of Environment, Volume 268, 2022,12777 [32]Parks, S.A., Guiterman, C.H., Margolis, E.Q. et al. A fire deficit persists across diverse North American forests despite recent increases in area burned. Nat Commun 16, 1493 (2025). https://doi.org/10.1038/s41467-025-56333-8
71	3	The question of forest management and its role on wildfire frequency and intensity is interesting and deserves further study. We agree	
80	1	The global mean sea-level was increasing at a rate of 0.08 inches/yr in 1993 compared 0.18 inches/yr in 2023, almost double the rate[33], which is approximately what is needed to meet the NOAA projections by mid-century and seems plausible. We discuss the NOAA projection for a specific site in the context of high-quality, long-term tide gauge data, but offer no comment on its plausibility. Extrapolating satellite-derived accelerations post 1993 is a perilous business given the well-documented variability of GMSL rates on multi-decadal scales	[33]Hamlington, B.D., Bellas-Manley, A., Willis, J.K. et al. The rate of global sea level rise doubled during the past three decades. Commun Earth Environ 5, 601 (2024). https://doi.org/10.1038/s43247-024-01761-5

88	3	A possible reason the method used by IPCC (optimal fingerprinting) can be considered to address McKitnick criticism is in [34] We have added citation Chen et al. They mostly just reiterate McKitrick's points. They propose a resolution to one part of the problem but it requires very restrictive assumptions.	[34]Chen, H., Chen, S.X. & Mu, M. A statistical review on the optimal fingerprinting approach in climate change studies. Clim Dyn 62, 1439–1446 (2024). https://doi.org/10.1007/s00382-023-06975-5
92	4	The role of clouds remains the single most uncertainty in climate modeling, I am glad this was acknowledged here. Agreed	
93	3	The substance of this paragraph was addressed in my comments in earlier sections. Some of the claims made here are either exaggerations of the usual practice (RCP8.5 being referred to as BAU) or the comment about not fit for purpose (a comment extracted from a publication that is calling out for cloud resolved models. Presumably the reviewer agrees RCP8.5 should not be used as a BAU scenario, so we are in agreement. The Palmer and Stevens paper nonetheless says the models are not currently fit for purpose, an observation echoed by the Nissan et al paper cited.	
105	2,3,4,5	The problem with both the FACE studies and the soybean. Maize and wheat studies cited here are that they don't consider the effect of increase in temperature, changes in precipitation, humidity and other environmental factors along with CO2 increases. These compound effects have been shown in wide number of studies [35] [36][37][38][39]. A meta analysis of the compound effects shows that increase in CO2, along with temperature, precipitation changes effects the quality of the cereal and yields[40]. Another recent study evaluated the impacts on C3 and C4 crops and conclude that CO2 enrichment for C3 crops could increase but will be compensated by temperature increase. CO2 fertilization effect was found to be small for C4 [41]. It is important therefore that we consider the compound effects on crop yields and not just focus on CO2 enrichment. The reviewer is correct that compound effects need to be considered, and indeed one of the problems with a lot of econometric papers on climate change and agriculture is they only look at heat and ignore the CO2 enrichment (Taylor and Schlenker being an important exception). Since our remit was impacts of CO2 emissions a brief discussion of FACE plot experiments and other CO2-only experiments is on topic. We discuss meta-analysis of multivariate (compound) experiments in Section 9.3.	[35] Ruiz-Vera UM, Siebers M, Gray SB, Drag DW, Rosenthal DM, Kimball BA, Ort DR, Bernacchi CJ. Global warming can negate the expected CO2 stimulation in photosynthesis and productivity for soybean grown in the Midwestern United States. Plant Physiol. 2013 May;162(1):410-23 [36] Levine LH, Richards JT, Wheeler RM. Super-elevated CO2 interferes with stomatal response to ABA and night closure in soybean (Glycine max). J Plant Physiol. 2009 Jun 1;166(9):903-13. [37]Večeřová K, Oravec M, Puranik S, Findurová H, Veselá B, Opoku E, Ofori-Amanfo KK, Klem K, Urban O, Sahu PP. Single and interactive effects of variables associated with climate change on wheat metabolome. Front Plant Sci. 2022 Oct 10;13:1002561. [38]Thomas, J.M.G., Boote, K.J., Allen, L.H., Gallo-Meagher, M. and Davis, J.M. (2003), Elevated Temperature and Carbon Dioxide Effects on Soybean Seed Composition and Transcript Abundance. Crop Sci., 43: 1548-1557. https://doi.org/10.2135/cropsci2003.1548 [39] Lesk, C., Anderson, W., Rigden, A. et al. Compound heat and moisture extreme impacts on global crop yields under climate change. Nat Rev Earth Environ 3, 872–889 (2022). https://doi.org/10.1038/s43017-022-00368-8 [40] Ben Mariem S, Soba D, Zhou B, Loladze I, Morales F, Aranjuelo I. Climate Change, Crop Yields, and Grain Quality of C3 Cereals: A Meta-Analysis of [CO2], Temperature, and Drought Effects. Plants. 2021; 10(6):1052. https://doi.org/10.3390/plants10061052 [41]Rezaei, E.E., Webber, H., Asseng, S. et al. Climate change impacts on crop yields. Nat Rev Earth Environ 4, 831–846 (2023). https://doi.org/10.1038/s43017-023-00491-0

106	1	Taylor and Schlenker 2021 also note that 'Climate change will likely have negative impact on agriculture in aggregate, especially in regions exposed to extreme heat. And the CO2-driven yield increases may be offset by effects on food nutrition and quality'. However, the results for US have been a net positive in the recent past but not true in the lower latitudes. Extreme heat may be a net negative, but thus far the overall effects have been positive. Regarding nutrition loss see Section 9.4	
111	1,2	The criticism of NOAA Billion dollar map is likely warranted as it was never completely transparent how the data was generated. However, changing the baseline assumption and refactoring the data using a different set of criteria to make the effects smaller also doesn't make sense. We should continue collecting this data and make the data accessible for researchers and peer review. Figure 10.1 doesn't address these issues, it is another methodology with unknown provenance of the data. We agree that data collection, dissemination and transparency are key. Fig 10.1 is traceable as an indicator though we don't regard it as the final word on the subject either. .	
117	3	Climate change can be expected to increase cold weather extremes in regions that have not been exposed to these effects The reviewer's point is unclear	
118	3	The same Nobel prize winning model in its most recent study concludes that [42] "We conclude with three results relevant for climate policy. First, both current policies (base run) and the extended Paris Accord fall short of limiting global warming to 2 °C or to the cost-benefit optimal level. Second, the economic stakes in global climate policy are substantial, with estimated net present value of economic benefits around \$120 trillion from the cost-benefit optimal policy. Third, once differences in discounting are considered, the baseline DICE-2023 estimate of the social cost of carbon (\$66/tCO₂ for 2020) aligns closely with other recent estimates". Obviously this is the latest and the current version of the model and these results are quite different from those discussed on this page. These conclusions should also be included in this discussion to avoid selective reading of the literature. We discuss Barrage and Nordhaus (2024) on p. 121.	[42]L. Barrage, & W. Nordhaus, Policies, projections, and the social cost of carbon: Results from the DICE-2023 model, Proc. Natl. Acad. Sci. U.S.A. 121 (13) e2312030121, https://doi.org/10.1073/pnas.2312030121 (2024).

120	1	Similar empirical studies [43] point to "Using an empirical approach that provides a robust lower bound on the persistence of impacts on economic growth, we find that the world economy is committed to an income reduction of 19% within the next 26 years independent of future emission choices (relative to a baseline without climate impacts, likely range of 11–29% accounting for physical climate and empirical uncertainty). These damages already outweigh the mitigation costs required to limit global warming to 2 °C by sixfold over this near-term time frame and thereafter diverge strongly dependent on emission choices. Committed damages arise predominantly through changes in average temperature, but accounting for further climatic components raises estimates by approximately 50% and leads to stronger regional heterogeneity. Committed losses are projected for all regions except those at very high latitudes, at which reductions in temperature variability bring benefits. The largest losses are committed at lower latitudes in regions with lower cumulative historical emissions and lower present-day income". This study uses more of the daily temperature precipitation from 1600 hundred locations world wide instead of global means. There are numerous studies that show the cost, many described in the COP 21 and follow-on meetings The Kotz et al. paper is subject to a cautionary notice at the Nature website that “the reliability of data and methodology presented in this manuscript is currently in question.” https://www.nature.com/articles/s41586-024-07219-0 The literature showing growth effects of temperature increase is pretty robust. And though we don’t cite it, there is a new paper just accepted at Climate Change Economics by McKittrick and Devina Lakhtakia adding to the evidence using 2 newly-constructed global data bases.	[43] Kotz, M., Levermann, A. & Wenz, L. The economic commitment of climate change. Nature 628, 551–557 (2024). https://doi.org/10.1038/s41586-024-07219-0
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Page	para	Comment or Suggested Edit
		The report indicates numerous examples of uncertainties in climate science. It would be extremely helpful if these uncertainties were made more explicit, listed in a concluding section, and prioritized in some way - what are the top 10 priority research areas? If the opening remarks by Secretary Wright and the title pointed to uncertainties and the need for more research, I believe this report will be better received. As I read the report and left review comments below, I bolded items where I gather the authors imply that research is needed. Consider including these kinds of statements throughout and adding a summary. An interesting suggestion but this must be deferred to a separate report.
viii	3	This would be more correct: "Some scenarios of future CO2 emissions overestimate observed levels" Sentence has been removed
viii	5	This would be more correct: Some detailed climate models run "hot" in their simulation of the climate of the past few decades, while many have underestimated the amount of surface warming. More research is needed to select the most skillful and reliable models. The need for more research on model development is implicit. Again, this would be a good topic for a separate report.
viii	6	Need reference for: "Claims of increased frequency or intensity of hurricanes, tornadoes, floods, and droughts are not supported by historical data." More research is needed to identify how frequency and intensity of weather events are affected by environmental conditions. The ES statements are all supported by the document chapters We have added reference to the specific sections in the revised summary.
4ff		It is misleading to separate the photo-chemical effects of CO2 from the temperature effects. Extreme heat is hard on plants, causing them to lose water, close stomata, etc. It depends on the plant and the degree of heat. More research is needed to understand how the temperature (mean and variability) affects plant productivity and resilience. 1st paragraph of Section 2.1, Added sentence "Here we focus just on CO₂ fertilization; research on combined effects due to temperature and precipitation changes are discussed in Chapter 10."
7		Again it is misleading to separate the CO2 and the temperature effects on the oceans. The warming surface waters is having significant impact on ocean fish and habitats due to the overall increase in global temperatures This section is specifically on changing alkalinity. We haven't included a review of temperature effects on fish populations: it is one of the impacts topics we were not able to survey.
14	4	More accurate to say "because their effect remain largely unknown". Good examples include natural aerosols (sea salt, dust, biogenic aerosols). Are there others to mention? More research is needed to understand radiative effects of both natural and anthropogenic sources of radiative variability throughout the atmospheric column. Sentence added: "Natural sources of global energy imbalance other than volcanoes and total solar irradiance (TSI) are not included in these graphs because their effects remain largely unknown."
17	figure	What scenarios are the models using in this figure? SRES, as stated in text, also others including Hansen A,B,C and others as described in the Hausfather et al. paper.
19		Vegetation is only one way that CO2 is accommodated by land processes, the other is through soils and microbial processes Microbial dynamics is complex and challenging to understand but may also be a way to boost CO2 absorption by soils (which also enriches the soil nutrients!). More research is needed to better understand how plants and soil systems remove CO2 from the atmosphere.

		Noted.
19	5	More research is needed to improve the understanding and representation of land systems, carbon and nutrient fluxes in models. Noted.
20		Carbon uptake by oceans and ocean ecosystems is less well studied and modeled. The lack of spread of carbon in ocean models may result from insufficient information, ocean biogeochemistry, ecosystems and model development. More research is needed to study and model carbon, nutrient and ecosystem processes and dynamics in ocean models. Noted.
		More research is needed to map warming trends in urban, non-urban and other environments and to ensure accurate representation of regional and global trends in temperature. Noted.
27	2	"This practice" - need to clarify whether this refers to "emergent property" or discarding. I believe the authors mean the latter, but it should be made more clear Sentence rewritten: "Parameter tuning to yield an ECS target was commonplace for the models used in AR4; modelers have moved away from this practice with time."
27	3	"assumed positive cloud feedback" - this is an emergent property too, based on simulation/observation. Should be rephrased to not use the word "assumed". Further research is needed to better understand and model how clouds change with temperature and what the feedback effects are on the radiative balance. We have deleted the word "assumed".
		Further research is needed to narrow the uncertainty on climate sensitivity, both using models and observations. Noted.
33		The text and figure refer to 33 models, which would include the best and worst. How much does the uncertainty/range change for a subset of best-performing models? The modeling community doesn't have a leaderboard of best-to-worst models. Some of the "prestige" models from the US and UK have very high sensitivities, but they are preferred by many users for particular applications.
34	figure	How many models are included in each case? High ECS 14, Medium ECS 11, Low ECS 13. Added to Figure caption.
36	figure 5.4	How are the lower and mid-troposphere defined? Standard definitions in the paper: LT surface to ~9km, MT surface to ~15 km. Added in the Fig caption.
37	4	"excess amplification" - amplification of what? And Figure 5.6 shows tropics, is this bias only tropical? Sentence changed: "Another important model-observational discrepancy is the excess amplification or warming with altitude..." The bias is only observed in the tropics but the amplification pattern is only predicted in the tropics. Also bear in mind the tropics is nearly half the atmosphere and is where most solar energy enters the climate system.
38		Further research is needed to improve how models represent clouds and dynamics; additional observations are also needed to improve these representations.

		Noted.
42		Further research is needed to improve how models represent planetary albedo to align with observations. Noted.
		The greater concern with hurricanes is the amount of moisture they carry and drop after landfall, i.e. flooding. While this is an active area of research, it is worth noting that this may be the bigger issue for hurricane change with warming This is covered in the AR6 assessment as quoted, as it's one of the intensity metrics. Currently too little data to assess for trends.
56-57		The concern for many are the extreme hot temperatures without night-time cooling that provides an opportunity for recovery. This section doesn't address this. In this regards, the focus on the difference between extreme hot and extreme cold is misleading when generalizing about decrease in extremes (figure 6.3.4) - the decrease is because we don't have as much extreme cold. This metric is covered by the data in Sct 6.3.3.
60		Combining heat and humidity as a measure of extreme heat is not unusual since it is this combination that is most impactful to human health - the body cannot cool if the humidity and heat are both high. Since a warmer atmosphere holds more moisture, and CO2 causes heat (and therefore moisture) to increase, this combination is a relevant assessment of the effects of CO2 on extreme conditions that make it difficult for people. Also combining with urban regions is helpful since that is where most people live. These points are not made in the report and are important. <u>S</u> entence be changed to read: "Given the heatwave definition and urban focus, while these increasing values since 1960 point to a growing human impact they are not informative about long term trends or..." Added sentence at end of paragraph (Irrespective of the ultimate cause of regional trends, heatwaves have important effects on society which must be addressed, as we discuss in Chapter 10.), which should address reviewer concerns.
		Patterns and variability of precipitation are poorly understood and models are particularly challenged to represent and predict precipitation, further research in this area is needed Noted.
		The authors rightly describe the extreme uncertainty regarding sea level rise. It would be helpful to add some information about the complex, highly nonlinear and uncertain processes involved with ice-sheet dynamics and ice-sheet - ocean interactions that are especially key for Antarctica. More research is needed to study and model ice sheet dynamics and ice-sheet ocean interactions. Noted. Canvassing ice sheet and ocean dynamics in that much detail beyond our scope but would belong in a separate report.
84	3	Further research is needed on climate variability, effects of ocean circulation, solar variability, model simulation of variability and statistical methods. Noted.
87-88		Anthropogenic aerosol effects may also influence the inflections in temperature in ways that are challenging to account for Noted.
91	2 and 3	Reductions in aerosol indirect (cloud brightening) effects may also explain the reduced planetary albedo, not just from ships but from reduced fossil fuel aerosols coming from the continents, China and east Asia especially. This paper describes the reduction in aerosols https://www.nature.com/articles/s41612-023-00488-y This is another area that needs further research! Noted.
94	table 8.1	What are the numbers in the 3rd column? Please include in the caption. Good point. Added to caption: "Numbers refer to footnotes in original source that specify locations or region-specific confidence levels."

95	2	I don't see an inconsistency between what Ch 11 and Ch 8 say. The first is about precipitation, droughts, tropical cyclones, heat - overall. The 2nd (ch 8) is about specific types of events in specific regions. Suggest to soften the statement about the contrasting assertions. Sentences at issue are “Evidence of observed changes in extremes and their attribution to human influence (including greenhouse gas and aerosol emissions and land-use changes) has strengthened since AR5, in particular for extreme precipitation, droughts, tropical cyclones and compound extremes” versus “No evidence of emergence in the historical period of a change in river floods, heavy precipitation, drought, fire weather, severe wind storms, and tropical cyclones”. these statements are manifestly in conflict.
		The science of attribution of extreme events is challenging and computationally expensive; this is an area where further research is needed with potential to use AI to improve statistics Noted. Not sure about the computationally intensive point: many just run univariate GEV models and overinterpret the results. AI won't fix the bad methodology.
104		This section seems to gloss over many key points. Certainly there are limits where extreme heat and drought (water is key) could be detrimental to crops. It also depends on which crops. There is extensive literature on how certain crop viability is shifting. So a region with particular crop experience and cultivation may no longer be able to sustain that agriculture. There is cost to shifting crops across regions and farmers that needs to be accounted for. And water is key - is there enough water in various regions for energy (power plants need water) as well as agriculture when conditions are very hot for sustained periods? The comment seems to be about the validity of the underlying literature rather than our summary of it. The econometric literature tries to synthesize patterns over large areas to get at overall trends, rather than the agronomy focus on specific sites and crops.
111		Severe weather continues to disproportionately impact lower income communities as well as business that requires outdoor exposure. A thorough analysis would need to include these points and I recommend adding this caveat to the section. This is specifically addressed in Section 10.3.2
		Related to my previous comment, deaths due to extreme heat conditions appear to be increasing, particularly for certain populations and for those with underlying health conditions (which can be hard to detangle when attributing mortality). For example https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2792389 Again this topic is specifically addressed in Section 10.3.2
114		An additional concern is if the grid fails under either extreme heat demands or cold/severe-storm events, the impact on communities will not be uniform and depends on grid infrastructure which can be better in more affluent communities Good point. We don't discuss what makes for grid stability versus instability, especially in the context of many jurisdictions closing reliable power plants and opting for intermittent renewables, but the correlation between extreme weather and the likelihood of power failure is an important topic.
		The impacts of sea level rise and coastal inundation on coastal communities and in low-lying countries should be addressed. This will have impacts particularly on certain countries/regions but also on world economics Good point. The topic is germane but runs into the limits of what we can cover in our limited time. To some extent it is covered in the economics chapter since IAM damage functions include effects of sea level rise on coastal areas.
		Research is needed to better understood the likelihood and impacts of various tipping points, including changes to ocean circulation patterns, ice sheet acceleration, sea-ice loss, die-off of tropical forests, thawing of permafrost, etc. Noted. Hopefully our discussion clarifies the different types of “tipping point” topics.

		Do the authors think it worthwhile for private or public research, such as at DOE, to seek breakthrough technology that might effectively remove massive amounts of CO2 from the atmosphere? No comment
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Chapter Number	Page Number	Approximate Paragraph Number	Comment or Suggested Edit
	i		In general, criticism and re-analysis of past research is always welcome. This report summarizes some substantial concerns from a small group of researchers. The report should be reframed to reflect this and I provide some suggestions in a later comment. I suspect that simply publishing this report will not offset the hundreds of reports and publications on CO2 and Climate that have come before it. But, new analyses and communication within and outside the research community could make a positive difference, should the findings in this report be substantiated. The DOE Office of Science BER could be provided an opportunity to address the research uncertainties in this document in a thorough and robust manner. Noted.
	iii	1	As someone who used to read the DOE reports on CO2 as a graduate student in the 1990s and then conducted numerous analyses of carbon on many topic areas which were later confirmed by numerous other analyses, it seems somewhat cavalier for DOE to issue one brief conclusive report on the "impacts of carbon dioxide emissions". I suggest the following option: Change the title to "Topics of Uncertainty on the Impacts of Carbon Dioxide Emissions on the U.S. Climate" or " An Assessment of CO2 Impacts on Climate to Guide Future Research ", and then use this report to drive research/analyses for each report chapter which would conclude in separate topical reports that could be finished within a year or two. In doing so, the DOE would positively contribute to addressing some of these standing issues and hopefully enable the nation to move forward in a more productive manner. Noted. New title: "A Critical Assessment of the Impacts of Carbon Dioxide Emissions on U.S. Climate."
	vii	Forward	I appreciate the perspective. It could be useful to add or edit the Secretary's Forward to indicate that "the report has been purposefully commissioned to researchers with alternative perspectives in an effort to address these perspectives and provide some closure for the American public, the US Economy, and US energy policy." I suggest this, because it will be very obvious that a handful of skeptics were chosen out of literally hundreds of extremely active and well-respected scientist. Addressing that upfront will immediately reduce criticism, and hopefully generate a positive environment to address these issues. Everyone would like to see convergence of findings on these issues. Noted. The suggested sentence is not well-phrased, but the reviewer is correct that everyone will see the names and know that the document is coming from a particular perspective. The problem is no such concerns were expressed when people with known biases got put in charge of NCA or IPCC chapters. The path to convergence starts with the wider community admitting that they've been keeping a lid on the necessary discussions. In any event, we do not have any control over the Secretary's Foreword
	viii	2	Any increase in greening from additional CO2 will likely be more than offset by longer growing seasons with higher temperatures (i.e., more days over 100). This causes serious risk to the US midwestern "bread basket", which is why this has been considered a national security concern. The data supporting this trend has been published a few times now in Science by a fellow out of Stanford, among others. Sources: Lobell and Field. 2007, doi: 10.1088/1748-9326/2/1/014002; also Sloat et al. 2020, doi:10.1038/s41467-020-15076-4 has a thorough introduction with many citations. The effects, including compound effects, on Agriculture are addressed in Ch 9

	viii	3	My understanding is that the upper bound of emissions (i.e., very high) is business as usual, with no mitigation, and a high-end of growth. It's a worst, yet plausible, case scenario. Similarly, the lowest emissions (i.e., very low) scenario includes technologies that don't yet exist including significant CO2 removal. Both are there to understand plausible extremes. The more likely scenarios are the low to high scenarios. I'm sure researchers are open to revisiting how things are bounded and presented if there are reasonable objections. It seems that within the expert community people are quick to set RCP8.5 aside as a fringe scenario. The problem is it dominates the impacts literature and the media coverage thereof. So the critical discussion herein is needed.
	viii	4	This may be true. But data driven analyses may not capture anticipated feedbacks. They attempt to by design. Limited by data especially ocean heat content, but they take it into account.
	viii	6	I am a big fan of data and meta-analysis. However, I'll note that I do not think forest management practices are overlooked. In fact, it is one of the main driving story lines (i.e., too much fuelwood exists, so we need to harvest more forest). There remains strong debate on the efficacy of fuelwood removal over large areas as an effective means of wildfire reduction. The key to this analysis is to look at whether the extent (not the numbers) of fires has grown and whether the burned areas are returning to forests or returning to brush or grassland. If it's the latter, then that is more likely due to regional changes in climate (temp and precipitation). Again the issue may be what experts discuss among themselves versus what's out there publicly.
	viii	8	I think we can point to sea-level rise in south florida, crop damage, and disease vectors fairly easily. I'm not aware of what costs are associated with these 3 items, but I suspect it's quite large. Dealt with in Ch 11 on economic costs and the SCC.
	viii	9	Yes, this is an important paragraph. Most scientists are not activists. Just because there is a science finding, scientists don't expect that to turn into policy. The public and the democratic system can determine the policy using an evidence-based risk/benefit analysis, just as noted here. Opening up this conversation (which should have been done decades ago) would be welcome and would better engage the public on this issue. DOE could in fact take a leading role here and help address a major national issue. A point of sincere agreement.
1	2		This is all generally correct. I would like to think this is common knowledge. Yes but bears repetition
2	4	1	Why use studies based on satellite sensors? I'm quite sure there are studies (again, out of Stanford) that use historic yield data (county-scale USDA data and global FAO data) with associated temperature and precipitation data. Those analyses do not agree with your findings here, I think. But, we can certainly pose these questions to our scientists that study and develop land models and develop a report based on all available data. I'll also note that for sometime data synthesis wasn't considered fundamental science and was therefore largely ignored. Enabling the researchers to conduct robust data analyses on this and other topics would be largely welcomed. See Ch 9 on Ag effects for the studies on yield data.
2	5	Figure 2.2	All data is interesting and useful for perspective and understanding. But isn't the main question whether we are driving up CO2 and temp at a rapid pace in the post-industrial era? This graph does not help answer that question. Figure 2.2 has been deleted.

2	7	3	Stating that increased aridity in drylands will not lead to decreased productivity seems a bit questionable. We can point to precipitation gradients from high to low precipitation that supports forests to grasslands to shrublands, respectively. Less water in general will mean less productivity; this can be seen in different forest compositions as well. The authors cite Zhang et al. (2014), but Zhang's main point is that the direct CO2 effect may be causing greening in drylands that offsets the decreased precipitation. This may be more specific to dryland vegetation, and Zhang et al. specifically state that this finding is relevant to north-east Brazil, Namibia, western Sahel, Horn of Africa, and central Asia. Zhang 2024, not 2014. The point here is to explain benefits of higher CO2 in terms of crop water productivity. Zhang acknowledges increase in desertification (as we note) but points to a global pattern of greening in arid areas.
2	9	3	I do not disagree with this observation of a decline effect, and I have seen it in some of the early biomass energy analyses that appeared in prominent journals and were then corrected over a few years. While it is unfortunate that some try to grab headlines with unsupported assumptions, it does seem that other researchers tend to provide counter arguments and analyses fairly quickly, indicating that the system does in fact work fairly well. Yes, part of the problem is the later counter-evidence gets relatively little attention, hence this report.
3	19	last	Yes, CO2 uptake by land processes have uncertainty associated with them. It's worth noting that DOE researchers (many of whom are retired now) were world-leading and making progress in this area, but nearly all work on CO2 uptake and emissions stopped 10-15 years ago due to political pressure and political concerns. The Carbon Dioxide Information and Analysis Center at ORNL, now cancelled, was a main contributor to the Global Carbon Project. Now the US is woefully behind and ceding expertise on this to the Europeans (as cited in this report). We are also ceding expertise on carbon monitoring via satellites to other countries. There's nothing necessarily wrong with this if this is where the US wants to go, but it's important to recognize that we have lost significant capacity due to policy changes over many years. We specifically recommend the government increase its focus on basic climate monitoring and data dissemination in the Concluding Thoughts section. The CDIAC was very valuable and we lament its closure.
5	44	1	Some of the early work on this topic was done by researchers at Stanford. But there are plenty of other papers. Here's one that came up in a quick search: https://www.pnas.org/doi/10.1073/pnas.0906865106 We discuss this paper in Ch 9.
5	44	1	Contradicting a number of large meta-analyses on the topic of decreased yields with increased temperature is ok. That's what science is all about. But it's going to have to be done in a more robust way than a couple paragraphs here with one or two citations. This section concerns temperature trends in the corn belt; the discussion of yields is in Ch 9.
6	47	chapter summary	This is very important. I have not dug into the data on extreme storm data (both numbers and intensity). Getting researchers together that disagree on a topic, analyze the data, and publish findings together can be very productive. DOE could sponsor a workshop and bring together a broad range of experts and find answers to extreme weather trends. Good idea

6	47	chapter summary	I conducted some analyses on wildfire years ago. I saw the bias in the university textbooks and in the wildfire working groups, who essentially went by textbook teachings. It was rare that people went back to the original data. The last time I checked the actual data (a good 10 years ago), I found that...you're correct...the number of fires had not changed much. What does seem to be changing is that the extent of fires has grown, and this is mostly attributable to hotter and drier conditions. I do not believe there is more fuel load now than there was before the US was settled. Arguing that harvesting will decrease fire is nonsensical; you have no idea where the lightning is going to strike and subsidizing the thinning of all forest in the western fire zone would be cost prohibitive. I think we need to stop using wildfire management as a justification for harvesting. If we want to harvest more, than do it, and stop using fuel load arguments (which is more of a concept than proven reality) as a reason to do it. The biggest issue here is encroachment of housing communities into the Wild-Urban Interface (WUI) and how we want to handle that with policies. Fire is really only bad if it's burning someone's house down. Otherwise, it's a natural progression in forest dynamics. Sources: Campbell et al. 2012. doi:10.1890/110057.; Schoennagel and Nelson. 2011. doi:10.1890/090199. Excellent comments. It's a big topic we can only glance at but we are trying just to get some pertinent data into the discussion.
6	57	6.3.2	The NCA5 is cited here and elsewhere. However, the USGCRP website that hosts the NCA reports has been removed. Hence, there is no way to read and review the referenced findings. This DOE report is therefore arguing against something that no longer exists, and that may appear questionable. Noted. Out of our control.
7	74	2	Given the satellite observed ice sheet dynamics, I'm not sure that ice sheet retreat is that hypothetical. Our reference is to hypothetical instabilities, i.e. massive disintegration.
7	all		This is the first time I have seen all sea-level rise estimates discredited by an offset from land subsidence. This is certainly a global dynamic that we would want to capture and understand in Earth system models, and DOE can look into this further with analyses and experiments if necessary. Noted.
8	86	all	This and other chapters cite the IPCC AR6. The IPCC provides a global process to address the issues and uncertainties in this report. Perhaps this report can set a path for pivoting research and re-engaging in a useful manner. That's a big ask.
9	104	chapter summary	The last sentence in this summary is not necessarily accurate. The authors cite Ainsworth and Long (2020) with respect to increased CO2 effects on crops. But, Ainsworth and Long (2020) indicate that increased temp and decreased precipitation will have negative impacts on crops, while increased CO2 may offset some of those negative effects. It is the impact of CO2 on climate and the subsequent impact on crops that is the concern; not the direct effect of CO2 on crops. Rewritten: "There is reason to conclude that on balance climate change has been and will continue to be neutral or beneficial for most U.S. agriculture

Chapter Number	Page Number	Approximate Paragraph Number	Comment or Suggested Edit
2	3	2.1.1, para. 2	Zheng not in reference list. Do you mean Zeng? Yes, fixed.
2	3	2.1.1, para. 3	"nearly double"? Why exaggerate? - it's a 76% increase. And they reported that future increase in GPP in extra-tropical northern hemisphere (e.g., U.S.) for [CO2] from 300 to 600 ppm of 42%, or 32% more than previous predictions (not 76%). Replace "nearly double" with "much larger than"
2	3	2.1.1, para.1	Zhu also explained that "other factors (OF) not considered in models, such as forest management, grazing, changes in cultivation practices and varieties, irrigation and disturbances such as storms and insect attacks, can be a cause of mismatch between observed and simulated LAI trends.... OF contributes the most to the observed LAI trend over 25.0% (increase) and 5.3% (decrease) of the vegetated area" We don't claim CO2 is the only factor.
2	3	2.1.1, para.2	This report is meant to focus on the U.S., so it would be more appropriate to discuss greening trends in the U.S. Fig. 2.1 shows that the trend in LAI across much of the U.S., with the exception of the Southeast, is less than the global average. Negative OF effects are mainly found in northern high latitudes (e.g., Alaska). Growing season warmth is the dominant factor in cold regions (10.1038/s41558-018-0258-y). Significant browning also is occurring in parts of Alaska (10.1175/EI-D-20-0025.1) But the effect is still positive. In Ch 9 we discuss US-specific evidence concerning CO2 and crop yields.
2	3	2.1.1, para.2	Greening of the Arctic can have important adverse consequences. Direct observations support that warming and increased vegetation cover in the Boreal-Arctic region showed a "robust increasing trend of CH4 emissions (+8.9%) with strong inter-annual variability. The majority of emission increases occurred in early summer (June and July) and were mainly driven by warming (52.3%) and ecosystem productivity (40.7%)." Yuan et al 2024 (10.1038/s41558-024-01933-3). We don't claim it's good or bad, only that it's been observed.
2	3	2.1.1, para.3	Wang et al 2020 (10.1126/science.abb7772) report a decline over recent decades in CO2 effects on global photosynthesis, possibly due to increasing nutrient interactions or interactions with effects on LAI. It's a controversial finding that attracted skeptical comments in <i>Science</i> regarding the validity of the satellite data and the statistical methods used https://www.science.org/doi/10.1126/science.abg2947 https://www.science.org/doi/10.1126/science.abg4420 https://www.science.org/doi/10.1126/science.abg5673 While the authors in reply defend the satellite data, they acknowledge they may not have dealt adequately with confounding non-CO2 factors. So, it seems premature to invoke this result.

2	4	2.1.2	Much of this information in this section is appropriately covered in chapter 9 on agriculture. Chapter 2 purports to have a wider focus (global and environment responses), so it should not dwell on responses of individual crop plants (crops account for only 15% of global GPP). There has been plenty written on ecosystem response to eCO₂, but evidence such as Fig. 2.3 is not relevant. All analyses of direct eCO₂ effects reveal an overriding interaction with other environmental factors (nitrogen and temperature), and global models show that eCO₂ only partially compensates for the negative effects of climate change on ecosystem carbon response. We struggled with how to divide material up in Ch 2 and Ch 9. The solution we came up with was that here we are addressing direct CO₂ effects, namely CO₂ fertilization; later we discuss Ag effects in more detail. Not everyone paid attention in high school biology. Figure 2.3 serves as an illustration of a point that non-specialists are often surprised to learn, namely that CO₂ is plant food.
2	4	2.1.1, last para.	Zhang, 2025 (10.1016/j.ecolind.2025.113762) reported that although vegetation cover was increasing, resilience against external disturbances (drought, heatwaves, wildfires) has simultaneously declined. They use the lag-1 autocorrelation coefficient as the measure of resilience based on Critical Slowing Down theory. The results are suggestive but very noisy and require a lot of assumptions to equate to a loss of ecosystem resilience. Since the authors also show that vegetation cover is increasing at the same time the results don't appear strong enough to merit any change in our discussion.
2	7	2.1.3, para. 2	Cheng did NOT report "increased plant growth"; they reported increased GPP. The distinction is fundamentally important, has been recognized for decades, and is completely ignored in this chapter. Cheng et al. did refer to an increase in Net Primary Production as well, but you are correct they focused on Gross Primary Production. The sentence has been rephrased "Similarly, Cheng <i>et al.</i> (2017) noted that increased Gross Primary Production from 1982 to 2011 due to rising..." and GPP has been added to the Glossary. More generally since GPP and NPP are closely correlated the use of "plant growth" is suitable.
2	6-7	2.1.3	This material is repeated in chapter 9 where it belongs. Here, it would be more appropriate to focus on how eCO₂ interacts with drought on ecosystem response (e.g., 10.3390/atmos12020212) We tried to avoid repetition but there is some. We discuss drought in Ch 8: since we don't see global and US trends, the issue of declining CO₂ fertilization during droughts isn't a key issue at this point.
3	19	3.2.2, last para.	Regarding the uncertainty in the land sink, a primary reason for this uncertainty is that the primary response of photosynthesis to CO₂ does not predict C sequestration because of strong interactions between CO₂ and climate, nutrients, stand dynamics, and other factors. That is why the almost complete focus in this report on crop plants and plant responses in greenhouses does not inform us about "CO₂ uptake by land processes" We aren't making any strong claims about the land sink, we only report the results in the Global Carbon Project. Not sure if the reviewer is challenging them or not.
9	104	all	This chapter is silent on agricultural effects on atmosphere and climate. Sokal and Kachel 2025 (10.3390/en18092272) conclude: "The current study demonstrated that agricultural activities significantly contribute to the emissions of three main greenhouse gases: carbon dioxide, nitrous oxide, and methane." Emissions from the Ag sector are included in the IAM results discussed in Ch 11.

9	105	9.2, para. 2	The section title is "Field studies..." but the next three paragraphs are primarily about responses of potted plants in growth chambers or greenhouses (with exception of Blandino, which was a field study and showed a much smaller response than the pot studies). There is an important reason that the field data cited in Blandino and in SoyFACE show a smaller response than data from the potted plants under artificial conditions. These data are barely relevant to the topic you are trying to address. FACE plot studies are field studies, and we also discuss other field studies. However, we also include some lab experiments. <u>Heading changed to "Field and laboratory studies of CO2 enrichment."</u>
9	105	9.2, para. 3, 4, 5	CO2Science.org website is a highly biased and unreliable website. They report on papers, or specific sentences in papers, that support their view and ignore conflicting reports or qualifying sentences. If there was another site that gathered that much data, we'd cite it. We'd need some evidence of actual bias to disqualify the CO2Science.org archive given the extent of its coverage.
9	105	9.2, para. 3	This is a report for the US. Why are you citing soybean studies in China when there is a major soyFACE study in Illinois? Yield in SoyFACE increased in eCO2 but declined with increasing temperature (10.1093/jxb/erac503). eCO2 did not result in water savings as hypothesized but rather increased soil moisture depletion. (10.1098/rstb.2024.0230) The Chinese study is on point regarding CO2 enrichment. The first study referenced by the reviewer (10.1093/jxb/erac503) only subjected soybean to elevated temperature without varying CO2, so it isn't relevant to our discussion. The second reference is to a general literature survey which doesn't appear to say anything different from what our chapter says.
9	106	9.2, para. 2	Ainsworth et al, 2025 (10.1093/jxb/erac503) state: "Early season stimulation in biomass at elevated [CO2] more than offset lower stomatal conductance in crops, resulting in greater depletion of soil moisture, instead of water savings [30,31]. Wheat tiller survival and grain filling was also reduced by elevated [CO2] under dry conditions [32]. The CO2 fertilization effect was also significantly reduced by growth at elevated temperatures in FACE experiments, again suggesting that high atmospheric [CO2] may not offset the negative impacts of global warming [29]. Thus, it may be that, to date, elevated [CO2] and the resultant climate changes have had net positive effects on agroecosystem productivity, but as climate change intensifies, there will be a shift towards net negative effects as has been suggested for natural ecosystems [3]." Our summary statement on the Ainsworth review is accurate regarding the CO2 effect. They raise the question of compound effects from simultaneous changes in CO2 and temperature. That topic is taken up in the discussion of the NBER study and Section 9.3

9	107	1st para.	Another study that should be cited is Hultgren et al, 2025 (10.1038/s41586-025-09085-w). "For all crops except rice, we estimate that warming will likely reduce global yields by 2050 (probability of loss ranges from 0.701 (sorghum) to 0.946 (wheat)... " "We estimate that global production declines 5.5×10^{14} kcal annually per 1 °C global mean surface temperature (GMST) rise (120 kcal per person per day or 4.4% of recommended consumption per 1 °C; $P < 0.001$). We project that adaptation and income growth alleviate 23% of global losses in 2050 and 34% at the end of the century (6% and 12%, respectively; moderate-emissions scenario), but substantial residual losses remain for all staples except rice." Regions with moderate average temperatures tend to suffer the largest yield losses. "Adjusting for CO2 fertilization does not qualitatively alter the structure of our findings ... but it does reduce the central estimate for end-of-century yield losses by 5.0– 9.5 percentage points... and increases the likelihood of positive aggregate effects." The Hultgren study came out after our draft had been complete. The headline results which generated massive publicity were based on RCP8.5 with no CO2 fertilization. One of our other reviewers wondered why we focused so much on the deficiencies of RCP8.5 when everyone knows it's a marginal case – this study is a good illustration of why. Fig 3 in Hultgren
9	108	1st	Reference to Ziska paper greatly mischaracterizes it. Ziska clearly indicates an effect of eCO2 on nutritional quality, but he indicates there is uncertainty in some of the mechanisms behind that response, including the simple dilution hypothesis. He states up front: "However, it is the direct effect of rising [CO2] on plant chemistry and stoichiometry that represents a continuing threat to the nutritional integrity of both human and animal systems." Ziska doesn't dismiss CO2, but he points out that nutrient dilution has also been observed under historical conditions in which CO2 was likely not the driver. Sentence rephrased "as is the evidence that nutrient dilution observed to date is entirely attributable to higher CO₂"
9	108	9.4, para. 1	Evidence for nutritional decline under eCO2 is widespread: Toreti et al, 2020 10.1038/s43016-020-00195-4) "A meta-analysis of 228 pairs of experimental observations on barley, potato, rice and wheat reported reductions in protein concentrations ranging on average from –15.3% to –9.8% under eCO2, while the reduction was relatively small (–1.4%) in soybean." AND Ainsworth et al 2025: "The positive 'CO2 fertilization' effect on crop yield is complicated by a decrease in many nutrients in elevated [CO2]. An analysis of 130 varieties of plants found that elevated [CO2] decreased the concentration of 25 important minerals by 8% on average, and the carbohydrate to mineral ratio was increased in these plants." We don't dispute any of this; it corresponds with what we say.
9	109		URL for Taylor and Schlenker paper is incorrect. It should be https://www.nber.org/papers/w29320. "papers" not "paper. Was this report peer reviewed? I cannot find it in a peer-reviewed journal. Thanks for the correction We don't think it has appeared in print anywhere other than the NBER series.

12	129	This chapter is highly distressing, but I suppose it encapsulates the whole thesis of the document. Apparently, there is no point in policies to reduce emissions (or make the necessary changes in energy policy to accomplish emission reductions) because it will make no difference to the atmospheric CO2 concentration or climate. So why bother? Would you have said this in 1970 (CO2= 326), 1990 (CO2 = 354 ppm), or 2010 (CO2=390)? Probably so. And in 30 years when CO2 is 500 ppm, will it be fair to look back and evaluate your apparent call for inaction in the statement here "And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate." But I suppose this attitude is justified if there is no adverse consequence and the only important effect of rising CO2 is to make little plants in greenhouse grow bigger (e.g., Fig. 2.3), and indirect effects on heat stress, drought, fires, sea level, etc. aren't worth discussing. The chapter rehearses some straightforward quantitative aspects of mitigation without making any policy recommendations. The reviewer is calling attention to actual problems finding mitigation strategies with positive net benefits.
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Ch	Page	para	Comment or Suggested Edit
1	2	full text	This chapter points out that the primary concern around human emissions of CO2 is that it changes the radiative balance of the atmosphere. The chapter also makes the points that CO2 has no toxicological effects on humans at current atmospheric levels, and that CO2 is necessary for photosynthesis, with the potential to stimulate plant growth at higher concentrations. These points are well-established scientific facts. Yes and experts know them but non-experts aren't necessarily aware of them.
2	3	3	It would be more reflective of the literature to say here that "Many studies over the past decade have confirmed a global greening pattern (increase in LAI) attributable to rising CO2 levels, changes in climate, changes in nitrogen deposition, land cover change, and other factors." We have added "in part" to sentence.
2	3	3	While the Zhu et al. 2016 study did find that 70.1% (+/- 29.4%) of the integrated global change in LAI was attributable to changes in CO2, most of the observed change in LAI is concentrated in the tropical forest regions of South America, Africa, and Indonesia, as shown in this report's Figure 2.1, reproduced from Zhu et al. In terms of the fraction of global land area influenced most by the factors considered in Zhu et al. 2016, effects on LAI from changing climate is the dominant factor (positive effects for 28.4% of land area plus negative effects on 4.7%, for a total area with dominant climate influence of 33.1%), followed by other factors not represented explicitly in the study or in the models (positive effects on LAI from other factors over 25.0% of land area plus negative effects over 5.3%, for a total area with other factors as the dominant effect of 30.3%), and then CO2 effects (23.2% of land area dominated by positive effects and 0.1% with negative effects, for a total of 23.4%). Since the report is focused on the U.S. it would be helpful to indicate the global context for the numbers reported. We have added new text "Other contributors included land-use changes, warming and nitrogen. The fraction attributable to CO2 was largest in the tropics; other factors played more dominant roles in CONUS."
2	3	3	The dominant factors related to changes in LAI over the U.S. (including Alaska) are land cover change (+LCC), climate effects (+CLI), other factors (+OF and -OF), and then CO2 (+CO2). There are more extensive regions where +CO2 is the dominant factor for the boreal forest zone in Canada. Given that, and given the explicit focus of the report on the U.S., it would be useful to call out in this section that the global greening pattern has distinct geographic variation in driving factors, and that over the target geography of the U.S. it seems to be dominated by factors other than increasing CO2. See my powerpoint slide 1 for a zoom on the area of interest from the Zhu et al. 2016 paper. Addressed with new sentence: CO2 fertilization effects are influenced by local temperature and nutrient and water availability, all of which vary regionally.
2	3	4	"Zheng et al. (2017) confirmed the pattern..." should be modified to say "Zhen et al. (2017) confirmed the pattern of observed greening..." As written, and in the context of the previous paragraph, the current text suggests that Zheng et al. 2017 confirmed the pattern of greening being related mainly to increased CO2, a factor which was not examined in their study. Changed: confirmed the pattern of greening, noting that over thirty years it had added 8 percent...
2	3	4	Without the addition of the appropriate context in the preceeding paragraph (my notes 3, 4, and 5) the remainder of this paragraph could be misinterpreted to mean that the impacts of greening on air temperature are attributable back to a positive effect of CO2 on greening. Rewording has addressed this.

2	3	4	The sentence "Greening has been observed globally but Chen et al. (2019) noted that China and India were exploiting it through land management changes" is misleading. Chen et al. (2019) shows that China and India are <i>causing</i> the observed greening in large areas by intentionally increasing the land area occupied by forests (China) and increases in harvested area in croplands, mainly due to multi-cropping, heavy fertilizer use, and expanded irrigation (China and India). It would be more accurate to say "Greening has been observed globally, but Chen et al. (2019) represent a disproportionate fraction of the total greening trend, accomplished through intentional increases in forest area (China), and expansion of multi-cropping, fertilizer use, and irrigation in croplands (China and India)." Changed: "Greening has been observed globally. Chen et al. (2019) show that in China and India much of it is driven by land management changes"
2	3	3 and 4	Given the changes suggested in these two paragraphs, it raises the question of whether the section title (CO2 and global greening) is itself misleading. That title wrongly suggests that all the content to follow is reflective of a direct influence of CO2 on the observed global greening trends, when the literature presents a much more <i>nuanced</i> interpretation. The changed to CO2 as a contributor to global greening
2	3	3 and 4	It would be worth noting in this section that the multiple remote sensing-based datasets for LAI changes have remarkable differences, especially when comparing the figure 2.1 reproduced from Zhu et al. 2016 with the MODIS-based data record from Chen et al. 2019 (their figure 1). That means it is difficult to place a lot of confidence in the attribution of changes in different regions to different factors. See my powerpoint slide 2 for a comparison of the four datasets used in Zhu et al. 2016 and Chen et al. 2019. Thank you for this information. It is an interesting point but gets into more specialized detail than is necessary for this report.
2	3	5	The authorship for the Haverd et al. 2020 citation is not correct in the References section for this chapter. The correct citation is: Haverd, V., B. Smith, J. G. Canadell, M. Cuntz, S. Mikaloff-Fletcher, G. Farquhar, W. Woodgate, P. R. Briggs and C. M. Trudinger 2020. Higher than expected CO2 fertilization inferred from leaf to global observations. Global Change Biology 26(4): 2390-2402 DOI: https://doi.org/10.1111/gcb.14950. Corrected
2	3	5	A more recent and more comprehensive study (Keenan et al. 2023) reexamined multiple data constraints and concluded that the model used in Haverd et al. 2020 (CABLE) is outside the likely range of CO2 fertilization effects, with higher CO2 fertilization than indicated by multiple independent constraints. At the very least this more recent paper should be cited in the report, with text indicating that the central estimate from the TRENDY models is more likely to be in the range of observational constraints than is the CABLE result. As it stands the report suggests that the latest science indicates that most models have underestimated the fertilization effect, and the literature doesn't currently support that conclusion. See: Keenan, T. F., X. Luo, B. D. Stocker, M. G. De Kauwe, B. E. Medlyn, I. C. Prentice, N. G. Smith, C. Terrer, H. Wang, Y. Zhang and S. Zhou 2023. A constraint on historic growth in global photosynthesis due to rising CO2. Nature Climate Change 13(12): 1376-1381 DOI: 10.1038/s41558-023-01867-2. Added sentence: However Keenan et al (2023) estimated a lower fertilization rate more in line with models.

2	4	1	The attribution analysis in the Chen et al. 2024 paper is very sensitive to the choice of multiple regression vs. partial correlation (their figures 3 vs S7, respectively), and in both cases they seem to misattribute the significant increases in LAI in India and China to CO2 rather than to changes in landcover and cropping practices. This kind of regression-based attribution is less informative than the model-based inference used for example by Zhu et al. 2016. The description of sensor calibration issues in this paper is also very cursory. It would probably be better to refer to the review paper of Piao et al. 2020 to support the claim of continued greening. Piao, S., X. Wang, T. Park, C. Chen, X. Lian, Y. He, J. W. Bjerke, A. Chen, P. Ciais, H. Tømmervik, R. R. Nemani and R. B. Myneni 2020. Characteristics, drivers and feedbacks of global greening. Nature Reviews Earth & Environment 1(1): 14-27 DOI: 10.1038/s43017-019-0001-x. Thank you for the comment. We have taken out the details about the Chen et al. analysis and say simply “Piao et al. (2020) and Chen et al. (2024) report that the greening trend continues with no evidence of slowdown, and CO2 fertilization remains the dominant driver”
2	4	2	The section 2.1.2 (Photosynthesis and CO2 levels) lacks coherence. It seems to be a collection of uncontroversial points about the ability of increased CO2 concentration to stimulate plant growth and reduce water loss through stomates. Figure 2.2 seems intended to show that the current levels of CO2 are not high compared to levels experienced in Earth's deep geologic past. A balanced treatment of the topic might call out the rate of change in CO2 concentration from human-caused emissions, and how both that rate and the absolute levels diverge radically from rates of change and ranges of variability over the past hundreds, thousands, and hundreds of thousands of years. See my powerpoint slide 3 for an example set of figures that might be included. In response to another reviewer, we have added the sentence “While the modern rate of change in CO2 is likely high compared to all prior intervals, the geological evidence is that plants and animals evolved under much higher CO2 levels than at present.”
2	7	4	The report suggests that the topics of CO2 fertilization and increased water use efficiency are not adequately treated in recent IPCC reports. In IPCC's AR6 WG I report there is an entire chapter devoted to an assessment of carbon cycle processes (Chapter 5, Global Carbon and Other Biogeochemical Cycles and Feedbacks). This is precisely where one would expect to find information about CO2 fertilization and water use efficiency. In the Executive Summary for the chapter is the following bolded headline: Increases in atmospheric CO2 lead to increases in land carbon storage through CO2 fertilization of photosynthesis and increased water use efficiency (high confidence). The associated Executive Summary text includes reference to two figures, three chapter sections, and a cross-chapter box all dealing directly with this topic. The Executive Summary text also references the important topic of nutrient dynamics and their interactions with fertilization and ecosystem-climate feedbacks, a critical nuance of the interaction of CO2 and vegetation productivity that is ignored in the report reviewed here. We acknowledge that the topic is addressed in the body of IPCC reports. But we draw attention to its omission from summary documents.

2	8	2	Section 2.2.2 (Coral reef changes) has a strong focus on past examples of early investigations that are later updated. There is also a note about the difficulty of publishing negative results, with a quote that this pattern "is true across all of science". Given the objective of this report, I suggest a shift in tone away from complaints about the kinds of papers that do and don't receive media attention, and instead highlight the latest synthesis of results about the likely future of coral reefs. A relatively recent synthesis paper (Cornwall et al. 2021) in a well-respected journal (PNAS) based on collated data from 233 locations worldwide projects that 37% of reefs will stop accreting and thus fail to keep up with sea level rise by 2050 under the low emissions RCP2.6 scenario, and no reefs would be able to accrete at a rate to stay ahead of sea level rise by 2100 under either RCP4.5 or RCP8.5. This analysis finds that most of the loss of net accretion rate is due to bleaching events, and a minority of the impacts are due to "direct physiological impacts of ocean warming and acidification on calcification or bioerosion". C.E. Cornwall, S. Comeau, N.A. Kornder, C.T. Perry, R. van Hooidek, T.M. DeCarlo, M.S. Pratchett, K.D. Anderson, N. Browne, R. Carpenter, G. Diaz-Pulido, J.P. D'Olivo, S.S. Doo, J. Figueiredo, S.A.V. Fortunato, E. Kennedy, C.A. Lantz, M.T. McCulloch, M. González-Rivero, [...] & R.J. Lowe, Global declines in coral reef calcium carbonate production under ocean acidification and warming, Proc. Natl. Acad. Sci. U.S.A. 118 (21) e2015265118, https://doi.org/10.1073/pnas.2015265118 (2021). This is a model projection study whereas for the very limited purpose of this section we are focusing on current and historical observations.
3	14	1	The study by Connolly et al. 2021 uses a linear regression approach to estimate the amount of variability in surface temperature trends that could be explained by total solar irradiance time series. Their approach is to first model the temperature trend with TSI as the dependent variable, and then compare the residuals from that fit to anthropogenic forcing factors. This is an obviously biased approach, and in fact a full paper was published the following year (in the same journal) laying out the erroneous methods and the faulty conclusions they produce (Richardson and Benestad 2022). Richardson, M. T. and R. E. Benestad 2022. Erroneous use of Statistics behind Claims of a Major Solar Role in Recent Warming. Research in Astronomy and Astrophysics 22(12): 125008 DOI: 10.1088/1674-4527/ac981c. While I agree with R&B that a partial regression is biased unless the regressors are orthogonal, Connolly et al. replied in 2023 at https://iopscience.iop.org/article/10.1088/1674-4527/acf18e in which they used updated AR6 data and reproduced their main result using multiple regression. However they also emphasized that it is only one of many possible results depending on choice of solar proxy and surface T record,
3	18	1	Section 3.2.2 (The carbon cycle relating emissions and concentrations). There is no new information or analysis presented in the chapter, and it relies heavily on Global Carbon Project information. Figure 3.2.3 is described as showing a seven-fold difference in the recent trend in land carbon sink estimates across land models, and this is given as a potential driver of uncertainty in future carbon cycle and climate change predictions. Variation among models is well known and is one of the reasons exercises like CMIP and GCP rely on multi-model ensembles when assessing the state of the science. The distribution of results looks fairly typical in this diagram, with a strong central value around 1.3 to 1.3. We're not claiming to have added new information, just reviewing what's out there.

12	129	3	The following sentence is misleading: "And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate." It is true that bringing global emissions immediately to zero would not reduce CO2 concentrations on short timescales. It is not true that this same scenario means no reduction in human influence on the climate. We must compare the zero emissions scenario to something, and the most meaningful comparison is the current trajectory of increasing emissions and the resulting super-linear increase in concentration. So by reducing emissions to zero we clearly avoid the expected increases in concentration and the expected increases in radiative forcing together with increased near surface air temperature and all the other expected consequences. So our change in action - going to zero emissions - does in fact have an immediate and growing human influence on the trajectory of the climate system. That is not an argument for reducing our emissions to zero tomorrow, it is just an argument for logic and clarity in how we talk about consequences of different actions. The sentence in the text is correct. It's also true to say that going to zero emissions would, over time, open up a widening gap between observed and counterfactual. But realistically we are only looking at marginal changes. The stock-flow mismatch is one reason IAMs have not recommended going to zero emissions.
12	129	5	Regarding the sentence "The practice of referring to unilateral U.S. reductions as "combatting climate change" or "taking action on climate" therefore reflects a profound misunderstanding of the scale of the issue." This makes the dubious assumption that when people refer to "combating climate change" or "taking action on climate" they are ignorant of the scale of the problem. Instead, it is probably more justifiable to assume that it is well-understood by most people who advocate for these local and national changes that the major emitters must act together to make a big difference in global emissions. It is at least worth considering, in the context of this report, that a path toward action at the necessary scale will require local and national action from a broad consortium, and that individual advocacy is a useful and necessary starting point for shifting the inertia of global policies. Sentence modified to read "The practice of referring to unilateral U.S. reductions as "combatting climate change" or "taking action on climate" on the assumption we can stop climate change therefore reflects a profound misunderstanding"

ch	pg	para	Comment or Suggested Edit
Overarching	Overarching	Overarching	• I would like to thank the authors for the opportunity to provide comment on this report. Providing decision-makers with information about the impacts of carbon dioxide emissions on the U.S. climate is critical as they face consequential decisions about the future of energy, agricultural, and environmental policy. Assessments of the science such as IPCC reports and the NCA benefit from undergoing robust review including expert review, public review, and government review with review comments and responses made publicly available. Similarly, important government reports and regulations undergo inter-agency review and are published in the Federal Register for a full notice and comment process and publish a public response to comment. While these processes are far from perfect, they offer the opportunity for improvement and help lend authority to the final products, and I highly encourage you to undertake a similar robust and open peer review process for this report to enhance the report’s credibility in the eyes of decision-makers and the public.
Executive Summary	viii	1	• There is a disconnect between the stated intent of the report by the authors in the preface, “whether carbon dioxide emissions endanger the U.S. public,” and this executive summary, as well as the organization of the report. Would suggest aligning by either reframing the focus in the preface to better match the organization of the report, or better aligning the report organization with the stated focus. Preface has been reworded and the statement eliminated. We have also changed the title to clarify this
Preface	ix	3	• “While the report is intended to be accessible to non-experts, we have omitted some introductory or explanatory material that can easily be accessed elsewhere. Nor have we attempted to survey entire literatures related to the topics covered.” • While this approach is understandable given the time constraints this report was produced under, given the level of visibility this report will have, it potentially opens up the report to criticism of being misleading by omission – focusing on areas where the authors disagree with the broader scientific literature and omitting areas large areas that are known about climate where there is less disagreement. See our responses to the previous comment
Preface	ix	3	• “We have focused as much as possible on literature published since 2020 and referenced previous IPCC and NCA assessment reports. We have also used data through 2024 where possible.” • This is a good approach for this report; however, much of the literature cited is from pre-2020, and many of the references to IPCC and NCA reports are to older reports (e.g. NCA 4 and IPCC AR 4&5) instead of NCA 5 and IPCC reports from the 6th assessment cycle. In these sections that heavily cite this older literature, it is not clear if the newer literature does not address these points or if the issues raised in the older literature are resolved or significantly changed in the newer literature. We have included reference to previous assessment reports where the analysis is insightful and not superseded by later reports. We note that we regard NCA4 as far more credible than NCA5

Preface	ix	3	• The IPCC’s mandate is to assess the scientific literature comprehensively, including a range of views, and report disagreements. This report has a tendency to selectively quote the IPCC focusing on disagreements and excluding areas where scientists agree. This approach risks giving a misleading picture of the state of the science through omission. A possible way to address this is to have a section summarizing areas of agreement by pointing to all statements of fact and high confidence statements from IPCC AR6 before digging into the more controversial areas with disagreement. This could be a short discussion about areas of agreement up front before explaining the focus of this report on these areas of disagreement, with the IPCC statements of fact and high confidence statements included in an appendix. • The report also includes only a very small subset of the literature since 2020. The authors should describe the approach to how they selected the literature included, and if possible, point to any systematic ways excluded literature could lead to different conclusions. • It is also notable that there a fair amount of new analysis in this report done by the authors that has not yet been peer reviewed. It would be good to flag these spots with a note about why these are needed while other related peer reviewed articles are excluded. This is addressed to some extent in the revised Preface
1	2	1	• If the goal of this report is to discuss links between CO2 and climate, this is an odd way to begin the report with a focus on differences between CO2 and criteria air pollutants. It clears up a confusion of language that persists
1	2	1	• “It is an issue of concern because of its potential effects on the global climate, a complex issue that occupies much of this report.” Suggest deleting the word potential as the existence of the effect is not disputed. Deleted: “potential”
1	2	4	• “But the primary concern about CO2 is its role as a greenhouse gas (GHG) that alters the earth’s energy balance.” Would add “warming the planet” to the end of this sentence as the qualitative effect is not debated and the concern is not about the energy balance itself but about the warming effects of the imbalance. Added: “warming the planet”
2	3	1	• “The recent decline in pH is within the range of natural variability on millennial time scales. Most ocean life evolved when the oceans were mildly acidic. Decreasing pH might adversely affect corals, although the Australian Great Barrier Reef has shown considerable growth in recent years.” • Note that the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) finds that pH decline has very likely emerged from natural variability. SROCC SPM A.2.5, “Open ocean surface pH has declined by a very likely range of 0.017–0.027 pH units per decade since the late 1980s, with the decline in surface ocean pH very likely to have already emerged from background natural variability for more than 95% of the ocean surface area.” We have left this out since it relates to attribution, which is beyond the scope of what we are addressing in this chapter
3	15	3	• “Instead, the IPCC has created various sets of scenarios meant to span a plausible range of possibilities” • Suggest changing “created” to “assessed” as the scenarios are created by the science community not the IPCC. We have changed the wording to “used”
3	16	4	• “The IEA trends, which are based on plausible extrapolations of current economic and demographic trends, run below the entire envelope of RCP projections, implying not only that RCP8.5 is dubious, but that even lower emission scenarios are unlikely.” • Burgess compares IEA to the two highest SSP-RCP scenarios, not to the full range. The last sentence of the paragraph is incorrect – the range in Burgess is only no climate policies which doesn’t include the lower RCPs. The Burgess diagram is poorly-labeled and hard to understand. The text has been revised added a reference to Pielke Jr et al 2022 which has a better presentation.
3	17	2	• “As of 2023, global CO2 emissions have been tracking well below SSP7.0 and are even below SSP2-4.5.” • Note that near-term emissions are not necessarily a good predictor of long-term emissions, as the latter will depend on changes in population, demographics, technology, and policy that do not have the same influence on near-term emissions. Noted

3	22	6	• “In summary, while there is clearly warming in the land record, there is also evidence that it is biased upward by patterns of urbanization and that these biases have not been completely removed by the data processing algorithms used to produce climate data sets.” • Quantitative info would be helpful here. How large is the warming? How large might the bias be? This is a topic that needs revisiting. The quantitative estimates are 15+ years old
4	26	1	• The Chapter Summary doesn’t really capture the full tax of the chapter. Would suggest: Defining ECS/TCS, reporting values for ECS and uncertainties/methods, then reporting values for TCS, preferably with a sentence on what those values imply The terms are defined in the chapter
4	26	2	• “This raising of the lower bound is less justified; evidence since the AR6 finds the lower bound of the likely range to be around 1.8°C.” • This isn’t really discussed comprehensively in the chapter. It is discussed, in context of Nic Lewis’ research
4	26	3	• “The climate’s response to increasing concentrations of CO2 is central to the scientific debate on anthropogenic climate change” • Suggest rewording this to, “The magnitude of the climate’s response...” As currently worded it could be a bit misleading since the qualitative effect (i.e. increasing CO2 concentrations lead to increases in global average temperature) is not disputed – the uncertainty is around the magnitude of the effect. Reworded
4	26	6	• The text sites Dayaratna (2016), but this should be a reference to Dayaratna (2017) as listed in the reference section. Fixed
4	26	6	• “If ECS is very high (above 4.5°C) immediate aggressive emission controls become more imperative, whereas no CO2 emission controls are economically justifiable for ECS below 2.0°C (Dayaratna et al. 2016, 2020).” • This could use additional clarification as there are low and now carbon technologies that can be economically justified based on cost of energy alone, depending on technology, location, etc. We have left as is. We are not aware of low or new carbon technologies that are affordable and scalable. Likewise. If energy conservation pays for the low carbon tech people would have been adopting them already.

4	26	6	• “Obtaining a precise estimate is impossible, so policy making needs to account for the uncertainty.” • The Social Cost of CO2 (SC-CO2) as used by the USG in regulatory impact analyses has always accounted for uncertainties in the ECS. EPA (2016) used a probability distribution for the ECS calibrated to IPCC AR4 findings (the most recent values available at the time) to harmonize the approach for the three models used (FUND, DICE, and PAGE). EPA (2023) updated the SC-CO2 in response to NAS recommendations (NAS 2017) to include a much fuller representation of the uncertainties in both ECS and TCR, and utilized a modular approach incorporating the Finite amplitude Impulse Response (FaIR) climate model, a reduced complexity climate model, with ECS and TCR distributions calibrated to IPCC AR6 to represent this uncertainty. • The Dayaratna (2017 & 2020) papers referenced here analyze sensitivity of a subset of the older models used in EPA (2016) to just ECS estimates. It would be helpful to address the advances in the broader literature that are discussed and represented in EPA (2023) as the focus of this report is on literature published since 2020. • EPA (2016) “Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 Interagency Working Group on Social Cost of Greenhouse Gases, United States Government.” https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf • NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of Most of the topics are touched upon in Ch 11. The newer EPA approach (e.g. the FaIR model) don’t reflect a fundamentally different approach than before. Will discuss below.
4	28	2	• “Because of concerns about model tuning and the high sensitivity to cloud parameterizations, the IPCC AR6 (2021) did not rely on climate model simulations in their assessment of climate sensitivity, relying instead on data-driven methods.” • AR6 WGI 7.5.5 states this a little differently. IPCC’s assessment wasn’t “directly informed” but “ESMs remain essential tools.” Our statement is ok as is
4	29	3	• “For AR6, the IPCC placed primary weight on the results of Sherwood et al. (2020)...” • The IPCC assessed a large number of studies, not just Sherwood (2020). Our statement is ok as is. Sherwood et al was predominantly relied upon
5	32	1	• It would be helpful for the reader for this chapter to start with a summary figure (e.g. like IPCC AR6 WG1 – SPM.1 or Fig. 3.4). Currently, the chapter jumps right into details that will be difficult for anyone who is not a climate scientist or already versed in these issues to understand or interpret. Too late in the process to add a new figure
5	33	Figure	• “Figure 5.1 CMIP6 Average surface temperature range across 33 models and standard deviation using SSP5-85 scenario.” • SSP5-85 is an excessively high scenario that is not representative of current expectations of emissions projections. Suggest changing the figure for on with data from a less misleading and more representative scenario. The use of 8.5 doesnt make much difference given high spread for historical period, but we agree this should be changed for a subsequent version of the Report

5	34	1	• There have been extensive published comments and responses on the approach used in Scafetta (2023). Can these be reflected here? • G.A. Schmidt, G.S. Jones, and J.J. Kennedy, "Comment on "Advanced Testing of Low, Medium, and High ECS CMIP6 GCM Simulations Versus ERA5-T2m" by N. Scafetta (2022)", Geophysical Research Letters, vol. 50, 2023. http://dx.doi.org/10.1029/2022GL102530 • N. Scafetta, "Reply to "Comment on 'Advanced Testing of Low, Medium, and High ECS CMIP6 GCM Simulations Versus ERA5-T2m' by N. Scafetta (2022)" by Schmidt et al. (2023)", Geophysical Research Letters, vol. 50, 2023. http://dx.doi.org/10.1029/2023GL104960 • Z. Hausfather, K. Marvel, G.A. Schmidt, J.W. Nielsen-Gammon, and M. Zelinka, "Climate simulations: recognize the 'hot model' problem", Nature, vol. 605, pp. 26-29, 2022. http://dx.doi.org/10.1038/d41586-022-01192-2 • S. Jain, A.A. Scaife, T.G. Shepherd, C. Deser, N. Dunstone, G.A. Schmidt, K.E. Trenberth, and T. Turkington, "Importance of internal variability for climate model assessment", npj Climate and Atmospheric Science, vol. 6, 2023. http://dx.doi.org/10.1038/s41612-023-00389-0 The Schmidt et al paper is a comment on a different paper of Scafetta's and focuses on his t-statistic, which isn't pertinent to the paper we cite (from Climate Dynamics). Regarding the Jain et al paper, Scafetta uses ensemble ranges within each ECS type and doesn't simply rule models out but shows that some perform well for TAS. Relevance of the Hausfather et al paper is not clear.
5	34	4	• "Spencer (2024) has also provided a useful summary of the Model-Observation mismatch by comparing trends in surface temperature data products with those in individual climate models, as summarized in Figure 5.3; most climate models show substantially more warming than the observations since 1979." • It is worth noting that IPCC projected temperatures do not use all models and instead focus on those that best reproduce observations. So while some models may show warmer or cooler temperatures than observations, that does not imply that projections from large assessments reflect those biases. Our text speaks to the collection of CMIP6 climate models; some of those with the largest amount of warming are widely used models from the US and UK
5	37	3	• "Hence, we assess with medium confidence that CMIP5 and CMIP6 models continue to overestimate observed warming in the upper tropical troposphere over the 1979–2014 period by at least 0.1°C per decade," • "Notably, despite the accumulation of evidence of excess model warming the IPCC assigns only medium confidence to the existence of a warming bias." • This reflects a more general issue with IPCC confidence statements where the inclusion of a quantification reduces the confidence they include. Here the full statement with the quantification of 0.1C per decade is assigned medium confidence whereas a statement about the existence of the bias without a specific quantification would receive higher confidence. Noted
5	39	Figure 5.7	• Does this update with data through 2024 use the same models that Christy and McNider (2017) used, or does it use updated versions for the models as well? This would be helpful to clarify here and in other places where figures are produced with updated data. Excellent catch. Fig. 5.7 uses CMIP-6 models, this is now stated in the caption as an update of Christy and McNider with CMIP6 output. Change made
5	39	3	• "The IPCC AR6 did not assess this issue." • Was this assessed in IPCC AR5? Many of the citations here could have been assessed then. Is there any more recent evidence on these issues that should be referenced here? IPCC has never addressed this issue with rigor, but does reluctantly note the discrepancy.
5	40	1	• Are there more recent papers or data available? All the info here is AR6 or pre-AR6, but more recent years have shown more surface warming. It would be interesting to show stratospheric temperatures for these more recent years as well to see how this relationship holds. Santer et al. (2023) has been added.

5	40	5	• Trends in snow cover depend on both changes in precipitation and changes in temperature. It would be helpful if these were discussed separately rather than showing the net effect for one region/season. Context for statement is that the models get it wrong
6	47	1	• This chapter relies solely on observations and does not include other lines of evidence, it would be helpful to discuss what these other lines of evidence indicate to avoid introducing potential biases (e.g. what do process based lines of evidence show?) Yes we rely primarily on observations. We have added some text regarding process-based analyses, notably in the section on hurricanes
6	47	1	• The chapter summary does not fully capture the chapter or the science. Suggest talking about the extremes affected by climate, the extremes not affected by climate, and those where the data isn't sufficient to establish a trend. We think our summary is appropriate
6	47	3	• “Over geologic time the climate system has generated an (essentially) infinite variety of weather patterns and extremes...” • Just because an event occurred before humans does not mean humans are not influencing the frequency or intensity of such events now. Additionally, if something has happened in the geologic record, but humans have never experienced it before, they may not be prepared for such an event. Changes in frequency and intensity are precisely the issues discussed Adaptation to extreme weather is a separate but important issue
6	50	Figure	• The figure heading has “@RyanMaue” in the title. Looks odd to have a social media handle in the figure. Is the source peer reviewed? We have added reference to an older publication by Maue that describes the analysis
6	52	4	• Insufficient data is different than no effects. It would be helpful to be clear in instances like this whether a conclusion is because the data supports it, or because there is insufficient data to say the opposite. This is covered in the last para of the section
6	53	Table	• Could you also show a similar table with hurricane precipitation? Not in this round. Very hard to get historical rainfall going very far back
6	53	5	• The last two paragraphs show findings from NCA4. With the interest in focusing on recent literature, what does NCA5 say about these issues? Does it not cover this issue, does it say the same thing, does it contradict this finding? NCA5 statements are discussed in the body of the text, see pp 57ff.
6	54	1	• The heading of section 6.3.1 is a bit misleading as this is partly driven by warmer winters and fewer cold days. For the CONUS, the heading is accurate as demonstrated with observational analyses
6	58	Figure	• Figure 6.3.5 shows the number of days greater than or equal to 95F in 6-year periods. Why show this in 6-year periods? That seems like an unusual choice. Would this look different with 5, 10, or 15 year periods? The time series is 126 years long, which is evenly divisible by 6. The point is to compress the depiction of interannual (i.e. natural) variability and examine slower changes. In our decimal system, 5 or 10 years is more commonly used, but with 126 years of data, we did not want to leave an “orphan” column (one with fewer years) compared with the entire time series. This is explained xplained in the Figure caption
6	58	4	• “We measure “Heatwave Days” here as the count of all days in May-Sep each year that exceed the 90th percentile for that day and that lie within a period of at least six consecutive days.” • Why six consecutive days? Would this look different for 5 days, a week, 10 days? Six days seems like an unusual period to pick. As noted in the text we use a metric defined in NCA4 for heat wave days. Regardless, whatever parametric choice is made (i.e. 5 days, 10 days, 85th percentile, etc.) the 1920s to early 1950s dominate the occurrence of heat wave days.

			Added: The pattern of results show below does not depend on the choice of reference period.)”
6	58	4	• The dependence on and subsequent choice of reference periods is worrying. Can multiple reference periods be shown to show the dependence? There will be no change in the fundamental result no matter which reference period is chosen. If the entire period-of-record is used to calculate percentiles, there will be fewer percentile exceedences than if a cold reference period is chosen (as was done in NCA4). However, the shape of the outcome will be the same.
6	59	3	• “The NCA5 directs readers to the website https://www.globalchange.gov/indicators/heat-waves (USGCRP 2023)” • Broken link. The link was live when the report was written, but the Reviewer is correct that it is now broken. Fortunately, we included the figure from that link to demonstrate the unusual start date (1961) and the fact that the sample contained only large cities.
6	61	3 to 6	• This reads as a very selective analysis. With a very tight time constraint and the fact our analysis required the construction of serially complete datasets, we selected regions that were called out by NCA5 and/or the IPCC AR6 as unusual. In future versions we shall have more regions to examine (e.g. upper Midwest, Central Plains, Texas Hill Country).
6	67	2	• Is this section suggesting that climate change is causing the decrease in tornadoes? No, this section doesn’t engage in attribution
6	68	7	• This is another place where it would be better to reference newer literature and NCA5 instead of relying on NCA4. What has changed since then? NCA5 mentions drought many times, but in anecdotal ways without metrics for testing. For example, NCA5 pg 1-23 states. <i>“Between 1980 and 2022, drought and related heatwaves caused approximately \$328 Billion in damages (in 2022 dollars). Recent droughts have strained surface water and groundwater supplies, reduced agricultural productivity, and lowered water levels in major reservoirs, threatening hydropower generation.”</i> This statement simply says that the demand for water was not met by the human-built systems which manage water supplies – there is no metric here that measures a change in the natural water supply. The statements on which we focus relate to whether the supply has been changing – a metric related to the climate system.
6	69	1	• Figure 6.7.1, is this the same indicator used in AR6? We have clarified the text to refer to meteorological drought. AR6 speaks mostly of “Agricultural and Ecological Droughts” which are defined in for various regions as <i>“Agricultural and ecological droughts are assessed based on observed and simulated changes in total column soil moisture, complemented by evidence on changes in surface soil moisture, water balance (precipitation minus evapotranspiration) and indices driven by precipitation and atmospheric evaporative demand”</i>., so we are unsure what specific metric is referenced.” Elsewhere it simply uses the term “drought” or “Meteorological and Hydrological Drought.” AR6 pg 1075 “A drought is a period of abnormally dry weather that persists for long enough to cause a serious hydrological imbalance (Glossary; Wilhite and Glantz, 1985; Wilhite, 2000; Cook et al., 2018). Most droughts begin as persistent precipitation deficits (‘meteorological drought’) that propagate over time into deficits in soil moisture, streamflow, and water storage (Figure 8.6), leading to a reduction in water supply (‘hydrological drought’). Increased atmospheric evaporative demand increases plant water stress, leading to ‘agricultural and ecological drought’.

			The best we can say is the AR6 used a different metric than shown in Fig. 6.7.1 that likely varied from region to region. However, Fig. 6.7.1 has high correspondence with drought-related impacts.
6	69	3	• “In summary there is no evidence of increasing drought frequency or intensity in the U.S. or globally over recent decades.” • This statement is not supported by the citations presented here. AR6 finds that there are trends in agricultural and ecological droughts and this section does not contradict that finding, so this general statement about there being no evidence of increasing drought frequency or intensity is misleading. • AR6 SPM A.3.2 – “Human-induced climate change has contributed to increases in agricultural and ecological droughts in some regions due to increased land evapotranspiration (medium confidence).” Footnote, “Agricultural and ecological drought (depending on the affected biome): a period with abnormal soil moisture deficit, which results from combined shortage of precipitation and excess evapotranspiration, and during the growing season impinges on crop production or ecosystem function in general (see Annex VII: Glossary). Observed changes in meteorological droughts (precipitation deficits) and hydrological droughts (streamflow deficits) are distinct from those in agricultural and ecological droughts and are addressed in the underlying AR6 material (Chapter 11).” We have added “meteorological” to last sentence
6	69	4	• “The IPCC has not provided an assessment of wildfires.” • AR6 WGII SPM discusses wildfire, and WG1 SPM discusses fire weather. • AR6 WGII SPM – B.1.1, B.1.4, Fig. SPM.2, Fig. SPM.3, B.5.2, B.6.2, C.2.3, C.4.2, D.4.2, • AR6 WGI SPM – C.2.4 Restated: The IPCC has not provided an attribution analysis of wildfires
7	75	1	• “The largest sea level increases along U.S. coasts are Galveston, New Orleans, and the Chesapeake Bay regions” • How much? Are there quantifications? The figures show this
8	83	3	• “AR5 Working Group II (Cramer et al., 2014) makes the following statement:” • What does AR6 say on this topic? The science on attribution has evolved since AR5. The AR6 did not make an analogous statement, but the challenges haven’t been resolved
8	84	6	• “There are three areas of substantive criticism of the IPCC’s assessment of the causes of the recent warming...” • Are there citations that can be included here or are these criticisms attributed to the authors? The section describes this adequately
8	84	6	• “IPCC’s policy-informing...” • This phrasing is a bit odd. IPCC reports are policy relevant but policy neutral. This phrasing the direct policy in some way. Deleted policy-informing
8	90	3	• “For comparison, the IPCC estimate of forcing from the increase in atmospheric CO2 compared to preindustrial times is approximately 2.2 W/m2 (Figure 3.1.2).” • This is comparing different time periods. Figure 8.2 includes data for 2023 and 2024, IPCC wouldn’t include the most recent years since it was published in 2021. Suggest updating from the IPCC data to Forster et al. (2024) that updates these indicators. • Forster et al. (2024) “Indicators of Global Climate Change 2024: annual update of key indicators of the state of the climate system and human influence” https://doi.org/10.5194/essd-17-2641-2025 Updated
8	92	2	• “It is not easy to justify a new positive low cloud feedback that began emerging in 2015.” • Explain why this is not easy? Added, “since there is no obvious feedback trigger starting in 2015” e

8	93	4	• “Other columns of IPCC Table 12.12 report on whether anthropogenic signals are expected to emerge this century under RCP8.5, the most extreme forcing scenario. We have omitted these columns for several reasons.” • Can this be done for RCPs other than 8.5? The point of these omitted columns in IPCC Table 12.12 was to show that for some extremes we may not see an effect now, but will in the future. As it is presented here it implies future changes won’t matter. Agree 4.5 would have been better, but this is a query that should be directed to the IPCC
9	104	1	• IPCC AR6 WGII has an assessment of agriculture (both in the SPM and in Chapter 5), and the IPCC also has a special report on Climate Change and Land, that are more comprehensive, recent, and cover a larger range of the literature than discussed here. Please update this chapter to reflect these findings. Need a more specific point of challenge. Other reviewers have brought up specific topics that were either addressed by revisions or are already covered. I think this is one area that goes under the heading of critiquing the mainstream, based on peer-reviewed literature.
10	110	4	• Section 10.1 rightly points out that technological advances have substantially reduced losses from extreme weather events. We are better at forecasting, preparing for, and adapting to extreme weather than we were in the past, and these advances all help reduce impacts. However, our ability to do this in the future depends upon preparing for future changes – we can’t simply assume adaptation will continue, we need to provide information on future risks and how those risks are impacted by climate change in order to inform continued technological advances and future adaptation. Noted
10	111	1	• “In May 2025 NOAA announced it has withdrawn the Billion Dollar Disaster product from publication (Pielke Jr., 2025).” • It would be better to cite an official government source from NOAA announcing this withdraw instead of a blog post commenting on it. Agreed, but this is the best information available from a well-published expert
10	111	2	• Losses from extreme weather and climate events are driven by climate risk (the physical events themselves), exposure to those risks (population and infrastructure impacted by these events), and adaptation to those events (technological advances in forecasting, warning systems, and resiliency). Understanding these risks requires disentangling these drivers in order to prepare for the future. Noted. Such a risk assessment is beyond the scope of this report
10	112	1	• There are additional citations that focus on the net effects of heat and cold related mortality that would be worth discussing and citing in this section. • EPA. 2024. Draft Technical Documentation for the Framework for Evaluating Damages and Impacts (FrEDI). U.S. Environmental Protection Agency, EPA 430-R-24-001. • Cromar et al., 2022. Global Health Impacts for Economic Models of Climate Change: A Systematic Review and Meta-Analysis. Ann. Am. Thorac. Soc. 19, 1203–1212. https://doi.org/10.1513/AnnalsATS.202110-1193OC • Hsiang et al., 2017. Estimating economic damage from climate change in the United States. Science 356, 1362–1369. • Mills et al., 2015. Climate change impacts on extreme temperature mortality in select metropolitan areas in the United States. Clim. Change 131, 83–95 The Cromar meta-analysis included only 7 studies for the US all published before 2015, and not all of them examined both hot and cold extremes. We think the citations we have, which includes the EPA, are adequate.
10	113	7	• Section 10.3.2 has good points about the importance of energy affordability and how energy poverty impacts adaptation behaviors. Cong et al. (2022) is another good citation for this section. • Cong, S., Nock, D., Qiu, Y.L. et al. Unveiling hidden energy poverty using the energy equity gap. Nat Commun 13, 2456 (2022). https://doi.org/10.1038/s41467-022-30146-5 Citation added

11	Chapter	Chapter	• Much of this chapter if focused on older literature on SCC and on applications that fall outside of how the USG has actually implemented SCC. This chapter would benefit from a more explicit focus on EPA (2023) as it represents the latest state of the literature on SCC, shows how the USG applies the SCC for regulatory impact analyses, shows how the USG updated the older IAG era SCC as represented in EPA (2016) in response to the recommendations in NAS (2017), shows how uncertainty is incorporated into SCC estimates, and discusses areas of the literature that are on the frontier, highly uncertain, and not ready to be incorporated into the official USG estimates. • As currently written much of this chapter is focused on these highly uncertain areas of the literature that are not incorporated into USG SCC estimates (e.g. tipping points, and climate change impacts on economic growth). EPA (2023) discusses these issues and why they are not ready to be incorporated into the official estimates. • Furthermore, EPA (2023) estimates of the SC-GHG does incorporate climate benefits such as CO2 fertilization and reductions in cold mortality discussed elsewhere in this report, and this should be noted and discussed. • Finally, this section ignores areas of real controversy in the calculation of SC-GHG as it is used by the USG – namely the question of global vs. domestic benefits and the treatment of discounting when valuing benefits to future generations. These controversial issues deserve far more attention in this report instead of spending so much space on issues on the fringe of the literature that are not even included in USG SC-GHG estimates. • EPA (2016) “Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 Interagency Working Group on Social Cost of Greenhouse Gases, United States Government.” https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf • NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of The new discussion by the EPA simply rehashes longstanding issues. Switching to separable models like FaIR isn’t an advance, because everything still comes down to choice of ECS, discount rate, etc. They add some new damage components but as discussed they jumped on the M17 findings prematurely. Ch 11 focuses a lot on non-SCC topics like the relationship between temperature and growth because that’s been the focus of a lot of research. It’s not the case that this work is too new to be incorporated into SCC calculations. Moore and Diaz (cited) for example incorporated the Dell et al result into an SCC model. The problem is that the temperature signal in growth isn’t robust so economists aren’t convinced it belongs in the models. We don’t discuss the global vs local benefits issue mainly because standard SCC models have always assumed we should measure global effects and we are not offering an argument otherwise.
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11	116-120	Section 11.1	• This chapter has a heavy focus on the relation between climate change and economic growth and how this relationship factors into the SCC. There is an ongoing debate in the literature about persistence in climate damages as measured by changes in economic growth over time; however, these persistence effects on economic growth are not considered in the most recent version of the SC-GHG used by the USG – EPA (2023). This chapter generally ignores the existence of EPA (2023), it is mentioned once in passing, and does not inform readers that these controversial areas of current research are not included in government estimates of the SC-GHG. • EPA (2023) page 58 says, “Given the statistical insignificance of the estimated coefficient on the productivity indicator in the published Howard and Sterner meta-analysis, the SC-GHG estimates presented in this report do not rely on Howard and Sterner’s specifications that include productivity effects. This is consistent with the authors’ recommendations in the published paper, to only consider the inclusion of the productivity impact in sensitivity analysis. However, the question of whether the effects of climate change impacts (e.g., temperature, tropical cyclones, and other extreme weather events) on the economy are only temporary or persistent is an active area of research. Over the past decade, a host of empirical studies have found evidence of temperature changes having persistent effects on the economy (e.g., Dell et al. 2012; Burke et al. 2015; Moore and Diaz 2015; Deryugina and Hsiang 2017; Ricke et al. 2018; Burke and Tanutama 2019; Colacito et al. 2019; Henseler and Schumacher 2019; Kahn et al. 2021; Kumar and Khanna 2019; Bastien-Olvera et al. 2022); this is an important finding because even small changes in economic growth rates accumulate into large economic impacts over time.” Some are discussed in Section 11.1.2 but McKittrick’s review is more up to date.
11	116	1	• “Economists have long considered climate a relatively unimportant factor in economic growth, a view echoed by the IPCC itself in AR5.” • It would be good to update this to the relevant conclusions in AR6 to reflect the more recent literature. AR6 didn’t have an economics chapter comparable to AR5.
11	117	5	• This section makes an important point, much of the public does not understand that climate impacts are relative to projected future without climate change and need to be put in the context of economic growth and a future where our decedents are better off than we are today. O’Neill (2023) is a useful citation here, finding that, “Climate change research and assessments, including the most recent IPCC report, paint an increasingly dire picture of the future. However, the assumption that the future will be worse than the present may be wrong for many aspects of human well-being.” • O’Neill, B.C. Envisioning a future with climate change. Nat. Clim. Chang. 13, 874–876 (2023). https://doi.org/10.1038/s41558-023-01784-4 Citation added
11	119	3	• “Overall they could not detect a temperature effect on GDP or GDP growth, and they estimated the 95 percent confidence interval for the impact on global growth as of 2100 even under the exaggerated RCP8.5 warming scenario spans .86 percent to +388 percent. In other words the net effect is likely positive but too uncertain to distinguish from zero.” • This finding from Newell et al. (2021) needs to be contextualized with their complementary finding that models excluding growth effects and relating temperatures to GDP levels are far more certain. This is important to include since the actual USG application of SC-GHG does not include growth effects. • Newell et al. (20201) states, “Models relating temperature to GDP levels yield climate impact estimates that are far more certain. The best such models imply GDP losses by 2100 of 1–3%, consistent with damage functions currently embedded in the major integrated assessment models that underpin the U.S. social cost of carbon.” The discussion in this section is focused on the effect of dT on growth. The discussion of how dT affects the level of income is what 11.1.1 focuses on. It’s very regionally heterogenous so the small global average reported in Newell et al. isn’t very insightful.
11	119	6	• “To summarize, economists consider climate a relatively unimportant factor in economic growth, a view echoed by the IPCC itself in the Fifth Assessment Report.” • Need to update to reflect AR6 findings. See above

11	121		• “The concepts of estimation and uncertainty do not readily apply to SCC calculations.” • The discussion of uncertainty in IAMs should reflect EPA (2023) which incorporated many major advances in the treatment of uncertainty in integrated assessment modeling. See section A.8 of EPA (2023) for a summary of the quantified sources of uncertainty in the SCGHG estimates presented in EPA (2023) • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf Our point is that the key underlying parameters are uncertain, and the range of SCC estimates merely reflects those uncertainties. The fact that the EPA proposes ways to compute distributions of the SCC doesn’t affect this point, it follows from it.
11	121	3	• “Economists use IAMs to compute the SCC. Two of the best known are the Climate Framework for Uncertainty, Negotiation and Distribution (“FUND”, Tol 1997) and Nordhaus’ DICE.” • This is old literature. Given the advances since FUND and DICE were the leading SCC models, and this report’s focus on literature post-2020, this section should be updated to focus on the models used to calculate the SC-GHG in EPA (2023) which represents advances over the approach used in FUND and DICE in response to NAS (2017) recommendations. Added a mention of this. • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf
11	121	4	• “and a ‘judgmental adjustment’ of 0.5 percent for excluded impacts at 3°C warming” • EPA (2023) is the most up to date representation of the USG approach to SC-GHG incorporating the recommendations of the NAS (2017), and EPA (2023) explicitly does not included an adder for missing damages. This is another example of this chapter focusing on older less relevant literature, and it really should be comprehensively updated to address EPA (2023). Barrage and Nordhaus is a (2024) paper. We don’t endorse their approach, just describe it. But in some respects the EPA approach is already obsolete because the new Administration has abolished the SCC. • EPA (2023), page 59 states, “the model runs performed for this report do not adopt a 25% adder (as used in the DICE model (e.g., Nordhaus 2017)) to account for unknown or missing damages for the meta-analysis-based damage module.” • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. • NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of

11	122	6	• “Abatement costs: IAMs represent the cost to the economy of reducing CO2 emissions. If CO2 emission reductions are assumed to be inexpensive, then the model will conclude that the optimal policy should aim for deeper emission cuts and vice versa.” • IAMs such as DICE are often used in a mode of calculating the optimal level of abatement where they do indeed compare the SCC with the marginal cost of abatement to find the optimum. However, these abatement costs are not part of the SCC calculation, and as used by the USG for the purpose of regulatory impact analyses, this feature of these IAMs is not used. Instead the USG has other more appropriate tools for analyzing the costs of specific regulations. This distinction is important here as the assumptions about the cost of emissions abatement does not have any bearing on the calculation of the SCC. The paragraph has been rewritten to clarify this.
11	122	7	• “For example, in 2023 the U.S. Environmental Protection Agency raised its preferred SCC value about 5-fold over the estimates it had issued ten years earlier. This is not because new data had been collected or better mathematical methods had been invented, but because new assumptions had been used, and the validity of those assumptions was a separate question.” • This paragraph contains the only reference to EPA (2023). First, the characterization of this update as only because new assumptions are used is factually incorrect. EPA (2023) represents a significant change to how the USG calculated the SC-GHG moving away from the FUND/DICE/PAGE models used in the IWG era (see EPA (2016)) to a modular approach as recommended by NAS (2017). This chapter needs to address the NAS (2017) recommendations and the EPA (2023) response to those recommendations to capture how SC-GHG was actually used by the USG and how the literature has evolved over time. The tabulations in EPA 2023 p. 81 show that if they had not changed the Ag productivity assumption and added a large mortality cost they’d have ended up with SCC numbers very close to the 2013 IWG numbers. Assuming very low discount rates did the rest. Using the FaIR model with the DSCIM and GIVE damage modules wasn’t the key change, it was • EPA (2016) “Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 Interagency Working Group on Social Cost of Greenhouse Gases, United States Government.” https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf § NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of
11	123	2	• “It should also be noted that the SCC is focused on the social costs of CO2 emissions from fossil fuel use. It does not measure the private marginal benefits to consumers and society from the availability of fossil fuels. Public willingness to pay for fuels of all types indicates the value to society of reliable, abundant fossil energy.” • Two points to make about this section. First, the benefits to society generally accrue from the provision of energy services, not from specific fuels.” A distinction without a difference in this context. Second, the private marginal benefit of the availability of fossil fuels or energy services is not part of the SCC because changes in the cost and provision of the energy services should be part of the other side of the cost benefit analysis. The SCC is used to characterize the benefits of GHG emissions abatement, and the changes in the costs and availability of energy services are part of the cost of emissions abatement. Agreed, changed the wording to clarify
11	125	5	• “the uncertainty of SCC estimates doesn’t mean that other regulatory measures are inherently better or more efficient.” • ‘regulatory measures’ is a poor word choice here as it can be confused with the regulation itself instead of the metric used to assess the regulation. Changed measures to instruments

11	123-125	Section 11.1	• Section 11.2.4 has an interesting discussion of tipping points. This is an active area of research in the field, however it needs to be noted that tipping points or tipping elements are not included in the SC-GHG as used by the USG, see EPA (2023). • EPA (2023), page 3 says, “For example, the modeling in this report omits most of the consequences of changes in precipitation, damages from extreme weather events, the potential for nongradual damages from passing critical thresholds (e.g., tipping elements) in natural or socioeconomic systems, and nonclimate mediated effects of GHG emissions other than CO2 fertilization (e.g., ocean acidification due to CO2 emissions, tropospheric ozone formation due to CH4 emissions). Importantly, this update does not yet reflect interaction effects and feedback effects within, and across, natural and human systems. For example, it does not explicitly reflect potential interactions among damage categories, such as those stemming from the interdependencies of energy, water, and land use. These interactions and feedbacks, and others, were highlighted by the National Academies as an important area of future research for longer-term enhancements in the SC-GHG estimation framework.” Not necessary to say this since EPA is on hold from doing SCC calculations
12	129	1	• This chapter summary is misleading as it is describing change from today’s temperature rather than the effect on future temperatures. A change from today’s temperature is the future temperature. Not sure what the objection is.
12	129	2	• “And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate.” • If global emissions were to go to zero tomorrow, CO2 concentrations would stabilize, and global temperature would be approximately constant. Net negative CO2 would result in reductions of concentrations and temperatures. In other words, while reducing global CO2 emissions to zero might not lead to near-term reductions in CO2 concentrations from today’s levels, it would stop future increases in CO2 concentrations. Consistent with what we stated.
12	129	3	• This section is focused on unilateral action, but needs to address questions related to collective action and individual actions by multiple parties when the benefits of abatement and the damages from emissions have extensive externalities. • Kotchen (2021) provides a theoretical perspective on the global vs. domestic SCC question and addresses questions related to how an individual country’s decisions are impacted by the expected choices of other countries given that GHG emissions are globally mixed the benefits of GHG abatement are shared widely. • Kotchen (2021). Which Social Cost of Carbon? A Theoretical Perspective. Journal of the Association of Environmental and Resource Economists. https://doi.org/10.1086/697241 An interesting line of thought but we can’t get into game theoretic models here.
12	129	4	• “Since that rate has been averaging about 50 percent of emissions in recent decades, a reduction of global emissions by 50 percent would (at least temporarily) halt the rise in atmospheric CO2.” • This may be addressed in earlier chapters that this reviewer has not read yet, but the standard framing is that stabilizing CO2 concentrations requires balancing emissions by sources and removals by sinks. Removals by sinks includes both natural sequestration and anthropogenic sequestration (e.g. afforestation if it can be done that increases the overall land sink removal, or direct air capture). It could be useful to clarify this here. The discussion is only an approximation for illustrative purposes
12	129	5	• “Lomborg (2016) estimated that full compliance with the Paris Accord would not stop warming, it would only prevent about 0.1C warming and delay hitting the baseline year 2100 temperature levels by about a decade.” • Note that the Lomborg (2016) finding is related to, “the of impact of the total, global emission cuts implied by all the submitted INDCs,” this is different than ‘full compliance with the Paris Accord’ as the INDCs analyzed in the paper are only the first round of Intended Nationally Determined Contributions submitted ahead of COP-21, and the Paris Accord requires additional Nationally Determined Contributions every 5 years. Since Lomborg (2016) only analyzes these INDCs, and parties have submitted two rounds of NDCs since then, suggest changing the wording here to, “... full compliance with initial commitments submitted ahead of the Paris Accord.” Changed.

12	129	Chapter	• [NOTE: this comment is long and could be difficult to read in excel. It is included here once as a full comment, then again broken into multiple parts for ease of reading. This is PART 1] • Section 12.1 is titled, “The scale of the problem,” is framed around contrasting criteria air contaminants with CO2 emissions; however, there really are three separate issues that need to be disentangled: Stock vs. Flow. • The challenge here is that abatement costs borne by people today benefit people in the future – temporal externalities. • CO2 emissions are a stock pollutant, so impacts depend on the cumulative emissions to date, whereas traditional criteria are a flow pollutant and impacts depend on the emissions at that point in time. Emissions of a stock pollutant going to zero will not affect impacts at that point in time, as the stock remains unchanged, but will have large impacts in the future as the stock will cease to increase until emissions resume; whereas emissions of a flow pollutant going to zero will immediately eliminate impacts, but impacts will have no lasting effects on future impacts as they will immediately resume when emissions resume. • The sentence at the end of the second paragraph of this section reads, “And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate.” This is conflating the expectations of how stock and flow pollutants work – if global emissions were to stop tomorrow, the fact that there would be no meaningful reduction in global CO2 concentrations is simply the nature of how stock pollutants work, but there would be very large impacts on future temperatures since the stock would cease to increase. Conflating isn’t the right word. We are pointing out the stock-flow issue. • The stock nature of CO2 emissions is a real challenge for justifying CO2 emissions reductions, but it is centered on justifying the costs of abatement being borne by people today in order to create a stream of benefits that grow over time and primarily accrue to future generations. This leads to questions important questions about how decision-makers should think about inter-generational discounting, and what costs should or should not be borne today for the benefit of future generations that will potentially be substantially better off. Dealt with in the IAMs section • It’s worth noting that since CH4 emissions are relatively short lived, they behave much more like a flow pollutant than a stock pollutant. If CH4 emissions went to zero, concentrations would fall relatively quickly, and the temperature effects would happen on a much shorter timescale, but if CH4 emissions fully resumed, concentrations would return to previous levels there would be no lasting impact of the previous reductions. This is to point out that the stock vs. flow distinction also happens between different greenhouse gasses and is not purely a distinction between GHG emission and criteria pollutants. The CH4 case is interesting and we haven’t looked at it. Also natural sources and sinks are complicated for CH4
12	129	Chapter	• [NOTE: this comment is long and could be difficult to read in excel. It is included here once as a full comment, then again broken into multiple parts for ease of reading. This is PART 2] • Globally mixed. • The challenge here is that abatement costs borne by people in one location benefit people in other locations – spatial externalities. • The next issue is that GHG emissions are globally mixed, so that emissions in any one location have impacts all over the world. This is a distinct issue from the stock vs. flow issue, as the CH4 example above showed a flow pollutant can also be globally mixed. One can also consider a stock pollutant that is not globally mixed, such as groundwater pollution that depends on the stock of contaminants accumulating in the groundwater not just the flow in any one time period as one would see in surface water pollution. • The globally mixed nature of GHG emissions is a real problem for justifying climate policy as the benefits of any one country’s actions primarily accrue to people in other countries. Conversely, a country benefits from the actions of every other country, not just their own actions. This is a problem of game theory and collective action, as unilateral action may not be justified even if collective action would be. It’s worth noting that this isn’t just a problem of scale – these same problems arise for globally

			mixed CH4 emissions even though as noted above they behave more as a flow pollutant, and would arise for any globally mixed pollutant regardless of the scale of the problem. There is an extensive literature on transboundary pollution that explores these issues. Agree with all this, but discussing these points wouldn't change our overall conclusions
12	129	Chapter	• [NOTE: this comment is long and could be difficult to read in excel. It is included here once as a full comment, then again broken into multiple parts for ease of reading. This is PART 3] Scale. • The challenge here is that solving the problem requires enormous change and potentially enormous costs. However, individual actions need to be considered at the margin. • As discussed in this section and the comments above, stabilizing CO2 concentrations and stopping the increase in global mean temperature requires balancing anthropogenic emissions and removals by sinks. The level global mean temperature stabilizes at would generally depend on the cumulative CO2 emissions up to the point CO2 emissions on net go to zero (the stock of CO2 emissions), and the level of short-lived non-CO2 emissions at that time (the flow of non-CO2 emissions). This would involve an enormous change to the global energy system. The costs of this change would be highly dependent on the timing of reaching net-zero CO2 emissions – in 10 years by 2035 would involve crippling costs to the global economy, in 100 years by 2125 would involve a far more gradual transition and likely impose minimal costs when discounted back to today. • What is missing in this chapter is an acknowledgement that policy needs to be thought of at the margin. Do the marginal benefits of the policy equal or exceed the marginal costs? This is how economists think of these problems and the essence of how the government conducts cost-benefit analysis to inform decision-makers under E.O. 12866. The case study presented in section 12.2 poses the wrong two question. Showing that a policy's emissions reductions are small relative to global emissions, and the resulting impact on global temperatures is also small is tautological. No individual policy will solve climate change, but that does not mean that the individual policy is not justified. The relevant questions for decision makers are: (1) what is the cost of the marginal ton of emissions reductions by this policy? and (2) are those marginal costs smaller than the marginal benefit of a ton of emissions reductions? In practice, question (2) is very difficult to answer, and requires judgements about how to value benefits to Americans vs. benefits to the rest of the world, how to discount benefits that accrue to future generations, and how to consider the impacts U.S. actions have on the likelihood that other countries will take actions that benefit the U.S. These are difficult questions that need to be answered to justify climate policy, and this section would be improved by acknowledging that these are the questions that need to be addressed instead of the awkward argument that the problem is big, and individual policies are small therefore they can't be justified. Ch 12 is only focused on the scale problem. The reviewer is correct that even if the effects are small that doesn't mean they shouldn't be undertaken. Ch 11 is where the logic of cost-benefit analysis including marginal considerations is explored.

12	129	Chap ter	• [NOTE: this comment is long and could be difficult to read in excel. It is included here once as a full comment, then again broken into multiple parts for ease of reading. This is the full comment] • Section 12.1 is titled, “The scale of the problem,” is framed around contrasting criteria air contaminants with CO2 emissions; however, there really are three separate issues that need to be disentangled: § Stock vs. Flow. • The challenge here is that abatement costs borne by people today benefit people in the future – temporal externalities. • CO2 emissions are a stock pollutant, so impacts depend on the cumulative emissions to date, whereas traditional criteria are a flow pollutant and impacts depend on the emissions at that point in time. Emissions of a stock pollutant going to zero will not affect impacts at that point in time, as the stock remains unchanged, but will have large impacts in the future as the stock will cease to increase until emissions resume; whereas emissions of a flow pollutant going to zero will immediately eliminate impacts, but impacts will have no lasting effects on future impacts as they will immediately resume when emissions resume. • The sentence at the end of the second paragraph of this section reads, “And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate.” This is conflating the expectations of how stock and flow pollutants work – if global emissions were to stop tomorrow, the fact that there would be no meaningful reduction in global CO2 concentrations is simply the nature of how stock pollutants work, but there would be very large impacts on future temperatures since the stock would cease to increase. • The stock nature of CO2 emissions is a real challenge for justifying CO2 emissions reductions, but it is centered on justifying the costs of abatement being born by people today in order to create a stream of benefits that grow over time and primarily accrue to future generations. This leads to questions important questions about how decision-makers should think about inter-generational discounting, and what costs should or should not be borne today for the benefit of future generations that will potentially be substantially better off. • It’s worth noting that since CH4 emissions are relatively short lived, they behave much more like a flow pollutant than a stock pollutant. If CH4 emissions went to zero, concentrations would fall relatively quickly, and the temperature effects would happen on a much shorter timescale, but if CH4 emissions fully resumed, concentrations would return to previous levels there would be no lasting impact of the previous reductions. This is to point out that the stock vs. flow distinction also happens between different greenhouse gasses and is not purely a distinction between GHG emission and criteria pollutants. § Globally mixed. • The challenge here is that abatement costs borne by people in one location benefit people in other locations – spatial externalities. • The next issue is that GHG emissions are globally mixed, so that emissions in any one location have impacts all over the world. This is a distinct issue from the stock vs. flow issue, as the CH4 example above showed a flow pollutant can also be globally mixed. One can also consider a stock pollutant that is not globally mixed, such as groundwater pollution that depends on the stock of contaminants accumulating in the groundwater not just the flow in any one time period as one would see in surface water pollution. • The globally mixed nature of GHG emissions is a real problem for justifying climate policy as the benefits of any one country’s actions primarily accrue to people in other countries. Conversely, a country benefits from the actions of every other country, not just their own actions. This is a problem of game theory and collective action, as unilateral action may not be justified even if collective action would be. It’s worth noting that this isn’t just a problem of scale – these same problems arise for globally mixed CH4 emissions even though as noted above they behave more as a flow pollutant, and would arise for any globally mixed pollutant regardless of the scale of the problem. There is an extensive literature on transboundary pollution that explores these issues. § Scale. • The challenge here is that solving the problem requires enormous change and potentially enormous costs. However, individual actions need to be considered at the margin. • As discussed in this section and the comments above, stabilizing CO2 concentrations and stopping the increase in global mean temperature requires balancing
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		anthropogenic emissions and removals by sinks. The level global mean temperature stabilizes at would generally depend on the cumulative CO2 emissions up to the point CO2 emissions on net go to zero (the stock of CO2 emissions), and the level of short-lived non-CO2 emissions at that time (the flow of non-CO2 emissions). This would involve an enormous change to the global energy system. The costs of this change would be highly dependent on the timing of reaching net-zero CO2 emissions – in 10 years by 2035 would involve crippling costs to the global economy, in 100 years by 2125 would involve a far more gradual transition and likely impose minimal costs when discounted back to today. • What is missing in this chapter is an acknowledgement that policy needs to be thought of at the margin. Do the marginal benefits of the policy equal or exceed the marginal costs? This is how economists think of these problems and the essence of how the government conducts cost-benefit analysis to inform decision-makers under E.O. 12866. The case study presented in section 12.2 poses the wrong two question. Showing that a policy’s emissions reductions are small relative to global emissions, and <i>the resulting impact on global temperatures is also small is tautological. No individual policy will solve climate change, but that does not mean that the individual policy is not justified.</i> The relevant questions for decision makers are: (1) what is the cost of the marginal ton of emissions reductions by this policy? and (2) are those marginal costs smaller than the marginal benefit of a ton of emissions reductions? In practice, question (2) is very difficult to answer, and requires judgements about how to value benefits to Americans vs. benefits to the rest of the world, how to discount benefits that accrue to future generations, and how to consider the impacts U.S. actions have on the likelihood that other countries will take actions that benefit the U.S. These are difficult questions that need to be answered to justify climate policy, and this section would be improved by acknowledging that these are the questions that need to be addressed instead of the awkward argument that the problem is big, and individual policies are small therefore they can’t be justified.
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Ch	page	Para	Comment or Suggested Edit
2	5	Fig 2.2	The graph is not relevant to the discussion. It should only, at most, cover the time period since the last glacial maximum, which occurred ~20 kyr BCE, and common practice is to concentrate on the last 1000 years. Figure 2.2 has been deleted
3	11,12	Sec 3.1.1	There is no quantification of the effects of TSI and volcanic aerosols that would lead to modifications of the radiative forcing shown in the figures In Chapter 6 we discuss ranges of TSI forcing that even the IPCC acknowledges.
3	21,22	Sec 3.3	Many of the arguments and references are dated. Further, the challenge posed is to prove a negative, i.e. that the record used by AR6 is not biased by urban heat island effects. On the contrary, while verbally stating uncertainty, the authors cannot make a claim that the AR6 statement is false. Even if one were to accept the Soon, et al value of 0.89 deg C/century, the focus on the land surface warming completely neglects the contribution of the oceans to global surface temperature change, which must be considered in any discussion of surface temperature change. The underlying studies frame statistical tests appropriately to test for the presence or absence of an effect. Yes ,the literature is dated and the topic needs renewed attention. The question is bias in the land record, but no one is arguing all surface warming is due to urbanization.
4	30	Sec 4.4	The statement "TCR is more generally related to peak warming and better constrained by historical warming, than ECS." requires further context. While true that the "peak warming" rate achieves a maximum around 70 years, temperature increases continue for several centuries and approaches the ECS value asymptotically. Further, the Lewis (2023) arguments were placed in context by Sherwood and Forest (2024), that identified multiple recent ECS studies that showed, collectively, that the PDF in their original Sherwood, et al paper could not be narrowed. Additionally, the reference to Sherwood et al (2020) is incorrect. It omits many authors and the authors that are listed are not in the correct order. Reference to peak warming deleted.
5	37, 38	Sec 5.4	The analysis presented of the IPCC AR5 figure, Fig 5.6 in the current document, is outdated and should be removed. The issue IS addressed in the AR6, but not graphically, in the text reproduced by the authors. If the section is retained, it should be moved ahead of Section 5.3 to present the material in the correct order chronologically. The analysis in Fig. 5.6 matches the updated data in Fig 5.7, and it is relevant to show that the information was included in the AR5 but only in a figure in the Supplement. The order of presentation in the chapter is appropriate.
6	57	para 1	The conclusion "The rise in Tmin has been strongly related to the growing presence of manufactured surfaces around the weather stations over the last 100+ years (the so-called urban heat island effect; Section 3.3 and Spencer et al. 2025)." is only found in an author's self-citation of Spencer, et al, (2025) that does not appear in the references at the end of Chapter 6. Further, the trend of greater increases in Tmin relative to Tmax is documented and explained in Easterling, et al (1997). https://doi.org/10.1126/science.277.5324.364 ; Thorne, et al (2016) https://doi.org/10.1002/2015JD024584 . The trend cannot be attributed to UHI effects. We added citations to the literature to substantiate the point.
8	85	para 5	"... datasets with high TSI variability can explain more than 70 percent of the temperature variability since preindustrial times." Variability on what time scales? 11-year cycles? How would this impact the well documented surface temperature increase of > 1 deg C global temperature change since 1900?

			There is a whole spectrum of variability in TSI beyond the 11-year cycle. These are discussed in the papers we reference.
8	85,86,87	"Natural variability of large-scale ocean circulations"	The discussion neglects the influence of vertical mixing on surface temperature. The global ocean has warmed, as documented by increases in global ocean heat content, e.g. Murphy, et al (2009) doi:10.1029/2009JD012105 We do not understand the comment.
8	88,89	Optimal fingerprinting discussion	This section is hardly a balanced and objective review. The report authors are known opponents of optimal fingerprint approaches and have been a loud, but very small minority voice. It is interesting that even they conclude "...these analyses do not falsify results of the IPCC optimal fingerprinting method..." The point is that falsification would require redoing all the underlying studies. The findings however show that the method is flawed and the justification for relying on it is invalid.
8	90,91,92	Section 8.4	This discussion is incomplete and fails to take into account the extensive literature on cloud and surface albedo feedbacks.. There is an extensive discussion about the post 2015 period and recent record annual global surface temperatures, implying, but not stating, that recent changes are the result of natural variability, or decreases in atmospheric aerosol concentrations. Comparing the radiative forcing from these changes with long-term GHG forcing, particularly CO2 is misleading to the average reader. If the reduction in albedo can be tied to atmospheric cloud and aerosol changes, as the authors state, they cannot ignore the likelihood that the changes are the result of anthropogenic factors, i.e. sulfate aerosol reduction through cleaner technology and the well-documented positive low-cloud feedback. The discussion is incomplete because the underlying science is incomplete, as we emphasize. We are surveying a complex area of ongoing research without taking a strong position ourselves.

Full document			In the limited time allowed, this reviewer concentrated on sections related to the physical climate and climate change. Frankly, the document was discouraging. Secretary Wright wants a " ... a more thoughtful and science-based conversation about climate change and energy." I find that this report distorts the science in much the same way as the media coverage about which he complains. Most notable are the omissions or under-reported significant climate changes, such as sea-ice decline, changes in the global water cycle and increases in heat-stress due to increases in absolute humidity (from water-vapor feedback). Further, the examples used by the report authors are narrow and appear to be selected to emphasize uncertainty, while the more rigorously evaluated science that contradicts their limited discussion is ignored, perhaps because it does not fit their narrative. This is unfortunate, because I believe it detracts from the much needed discussion about the future, including energy policies, technologies and trade-offs. I encourage DOE to start the discussion by accepting the well-reviewed and broadly accepted scientific conclusions of the IPCC Working Group 1, with respect to the observations and analyses of climate change in the 20th and 21st centuries. Skepticism regarding predictions/projections of future climate based on posited scenarios is justified. As a member of the physical climate research community, I believe there are better uses for the models (and the computer resources they consume) than scenario projection simulations, to inform the discussion that is urgently needed about the future. Comments noted.
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Chapter Number	pg	para	Comment or Suggested Edit
Foreword	vii	4	The stated charge to the team was to summarize the current state of climate science, but in the Preface the team states that it chose to focus on topics that are downplayed in or absent from current assessment reports. To accurately describe the contents of the report, the Foreword should also state that the report is a summary of the things that the author team thinks have been downplayed in major climate assessment reports. Noted, the Preface has been modified. Our charge was not to summarize the whole of climate science.
Foreword	vii	8	The statement about climate change not being the greatest threat facing humanity is a value judgement. Since the Secretary criticizes others for blurring the line between scientific conclusions and policy recommendations in the second, fourth, and sixth paragraphs of this Foreword, it is hypocritical to offer a value judgement without clearly labeling it as such and noting that such conclusions must necessarily involve one's beliefs in addition to scientific information. We did not write the Secretary's foreword.
Exec Summ	viii	2	It is misleading (cherry picking) to only mention "global greening" (i.e., the influence of elevated CO2 on plant growth) here without also noting the impacts of elevated temperatures and changing precipitation patterns on ecosystem health and agricultural productivity. (This comment is also true of the underlying content on pages 3-7) This issue has been addressed with wording changes to acknowledge the other contributors.
Exec Summ	viii	2	It is misleading to state that ocean pH levels are within the range of natural variability. This statement is not true on the timescales governing the impacts of ocean acidification on ocean ecosystems and fisheries. (This comment is also true of the underlying content on pages 8-9) The statement has been removed.
Exec Summ	viii	3	It is inaccurate to say that "scenarios of CO2 emissions have tended to overestimate observed levels". As the authors themselves note on page 15, it is impossible to reliably predict societal behavior regarding energy production and other sources of emissions, so the climate science community has never provided or suggested that there is a single predictive scenario against which future emissions could be judged. Rather, there has always been a range of projected emissions scenarios, and emissions have always tracked within the envelope of those scenarios. The authors make a reasonable point in the full text about the large number of climate studies that have used RCP 8.5, whereas actual emissions have recently been closer to RCP 4.5. This would be a more appropriate finding to include here in the executive summary. The point being made here is that observations have tracked the low end of the envelopes, a problem going back decades. See Figure 3.2.1
Exec Summ	viii	4	Stating that climate models "offer little guidance on how the climate responds to elevated CO2" is at best an unjustified (and at worst a biased) judgement given that the authors chose to focus only on the shortcoming and deficiencies of these models, and do not account for the progress made in improving the ability of these models to reproduce many key aspects of observed climate change. The same is true for all of Chapter 5. It is informative for readers to see key ways in which models fail to match observations especially those most relevant for policy making. The continuing wideness of the range of responses is an important limitation to their fitness for purpose.

Exec Summ	viii	5	Stating that climate models "generally run hot" is an inaccurate and misleading summary statement. A large number of papers and scientific assessments have validated the ability of climate models to accurately simulate many major aspects of global climate. Like all models, climate models are imperfect, and some models have recently shown a tendency to produce higher climate sensitivities--the IPCC AR6 acknowledged this "hot model problem" and there has been considerable discussion in the scientific literature about it and its implications for impacts studies. But this is a relatively recent phenomenon, and there could be other reasons for the recent mismatch (i.e., under-estimates of the reduction in aerosol cooling due to air pollution controls). A balanced scientific assessment would also note, for example, that climate model projections from the 1970s and 80s have accurately predicting the observed trend in global temperature over the past few decades. Our statements are substantiated by the Figures in Ch 5 (especially Figs 5.2 - 5.4). As we discuss, the problem of the tropospheric mismatch goes back decades.
Exec Summ	viii	6	It is misleading and inaccurate to say that most extreme weather events do not show long terms trends. It is true that some kinds of extreme events, like tornadoes, have not shown appreciable or detectable changes, and that changes in wildfire must account for changes in land management. But a "summary of the current state ofthe science" should acknowledge that there is clear evidence that heat waves are becoming more frequent and more extreme, extreme precipitation and nuisance flooding are becoming more common, etc. (This comment is also true of the underlying content in Part II) The chapter presents a great deal of data that substantiates our summary statement. We also provide clear indications on heatwave trends including where they are increasing in frequency. Our assessments match those in the IPCC and NCA documents.
Exec Summ	viii	6	It is misleading to state that the aggregate sea-level rise trend in U.S. tide gauges is not accelerating, because as noted in the same sentence, there are significant regional differences in SLR (primarily due to differences in land subsidence), so only looking at domestic gague data is insufficient to determine if sea-level rise--an inherently global process--is accelerating, with regional factors superimposed on that global trend. There is clear evidence that global sea level rise is accelerating. Moreover, while land subsidence has offset sea level rise in some U.S. regions, the opposite is true in others, and in those reasons the combined effects of sea level rise and subsidence are posing considerable risks to people and infrastructure in those regions...but this important context is omitted. (The same is true of the sea level rise analysis on pages 75-78.) We state that global sea level rise has accelerated in recent decades. The reviewer needs to provide evidence for the claim of acceleration. SLR is a regionally-heterogeneous phenomenon and we discuss the differences by location. We present tide-gauge data for many locations so readers can see the situation for themselves.
Exec Summ	viii	9	Most of the sentences in this paragraph are not factual in nature. For example, the call for uninterrupted observations of the global climate system is a research recommendaiton that is outside the remit of this report and is not supported by text within the document. The same sentence also implies that current emissions scenarios are not "realistic", which is not a defensible statement given that historical emissions have tracked within the envelope of previous emission projections (see comment above and Figure 3.2.2), and argues that climate models should address biases and uncertainties, which is something that every climate modeling team already spends an enourmous amount of time doing. If retained, the non-scientific portions of this paragraph should be moved to the Preface, and the misleading statements should be corrected. The paragraph has been moved to the end of Chapter 12. See above regarding emission scenarios.

Preface	ix	1	The focus on "whether carbon dioxide emissions endanger the U.S. public" is slightly different from the stated focus in the Foreward on "the Nation's climate". This distinction is important because climate change and its impacts outside of U.S. borders can endanger the U.S. public both directly (e.g., global processes affecting sea level rise in the United States, or the impacts of climate change on overseas military installations) and indirectly (i.e., impacts of climate change on international agricultural production and trade dynamics). The reference to endangerment has been removed.
2	3	1	The two summary statements provide an extremely narrow and misleading view of "direct impacts of CO2 on the environment" (the chapter title). The most obvious direct impact of CO2, in the context of climate change, is its role in global radiative forcing, which is covered in the next chapter but not mentioned here. The chapter should at a minimum be retitled, but better yet combined with the following chapter which discusses other aspects of increasing CO2. The effect of CO2 on the climate takes up the bulk of the report.
2	3	2	It is misleading to state that ocean pH levels are within the range of natural variability. This statement is not true on the timescales governing the impacts of ocean acidification on ocean ecosystems, fisheries, and other processes. The evidence we cite shows that pH levels are in the range of natural variability. Whether the rate of change is, is much more difficult to establish because of the limitations of paleo records. Also the spatial heterogeneity is not subject to comprehensive measurement, which precludes straightforward assessment.
2	5	1	It is misleading to show (only) a graph of CO2 levels over hundreds of millions of years. These timescales are generally not relevant to processes and issues surrounding anthropogenic CO2 increases. For example the authors in multiple places make statements about CO2 levels during the last glacial maximum, but those fluctuations are undetectable on a graph with such a long timescale. The figure has been removed.
2	8	1	Acidification is not a misnomer...the word literally means to make something more acidic, which is what is happening. The authors may choose to argue that the term is misleading since the oceans are slightly basic, but that is not the same thing as a misnomer. We consider it a misnomer for the reasons stated. The oceans are not becoming acidic.
2	8	1	It is misleading and largely irrelevant to discuss ocean pH levels tens of thousands or millions of years ago, because that timescale is not relevant to the impacts associated with anthropogenic ocean acidification on ocean life. It is well documented that recent changes in ocean pH are happening ~100 times faster than natural fluctuations prior to human CO2 emissions, and marine species must adapt to changes in conditions on timescales of a few of their lifetimes, which is clearly not millions of years. The referee needs to provide specific sources for these statements. Also, it is a relevant point to make if current marine life evolved under conditions of much lower pH.
2	9	4	Similar to previous comment--changes in marine life over hundreds of millions of year has little relevance to the survival of marine species on decadal timescales due to anthropogenic ocean acidification. Are the authors trying to suggest that U.S. society would be well served by going back to conditions during the Jurassic? See earlier response.

3	13	2	The IPCC probably discounted the results reported in Connolly (2021) because that study included methodological errors that were documented in several subsequently publications, which the authors do not acknowledge. A serious assessment of TSI would not cherry-pick a single study, especially one that has been shown to include serious errors. The reviewer is probably referring to a comment by Richardson and Benestad, but Connolly et al. replied effectively to their critique.
3	14	4	It is unclear what the authors mean by "other natural sources of energy imbalance". If the authors are aware of a plausible additional source of energy imbalance they should state what it is rather than making vague statements without providing any evidence that such sources might exist. Surely the reviewer acknowledges that there are unknowns in the climate system
3	14	5	This is one of several places where the authors discuss the CO2 levels at which C3 plants begin dying in the context of the last glacial maximum. This is misleading, because there is no evidence that CO2 levels would have continued falling below the levels of the last glacial maximum, and irrelevant to the stated focus of this report, because they rebounded to 280 ppm many centuries before human activities began producing large amounts of CO2. The reviewer needs to provide evidence for the assertion that CO2 levels would not have continued falling.
3	15	1	The oceans and land surface absorb more like 60% of CO2 emissions. The 50% figure is repeated multiple times in the ensuing pages and should be corrected. We are unfamiliar with the 60% number; the sources with which we are familiar generally report numbers closer to 50%. The reviewer has not cited any sources for his or her statement.
3	20	2	The final sentence on this page is misleading and confusing as written. Most studies of the land carbon sink suggest that the rate at which it is increasing is declining, and several studies suggest that the ocean sink is declining. The authors should also explain the relevance of their statements here, because it isn't clear. Our statement is consistent with the sources we cite. Unfortunately the reviewer did not provide references.
4	26	6	The inclusion of a paragraph with high-level summary statements about climate policy here is confusing and inappropriate. This content belongs in chapter 11. We only make a brief introductory statement and otherwise defer the discussion to Ch 11.
4	29	1	The point about observed global temperature trends being consistent with both high-ECS high-aerosol and low-ECS low-aerosol worlds is an important one. It would be good to acknowledge that uncertainty in ECS is not just due to uncertainties in climate models, but also the lack of accurate measurements of pre-industrial aerosols and thus anthropogenic changes in aerosol forcing. And this uncertainty cuts both ways--if we live in a high-ECS world that has been "masked" by strong aerosol cooling, reducing air pollution could result in rapid warming (and this may be linked to the "hot model" problem as well). Agreed
4	29	2	The point about ECS values derived from past climate states (especially cooler ones) possibly not being totally representative of the current climate is another good point, one that would be good to acknowledge in their earlier and later discussions about uncertainty and the rationales for emissions reductions (e.g., on page 26 and in Chapter 11). Agreed.

4	30	1	The relatively shallow treatment on TCR relative to ECR here is puzzling, since the authors acknowledge that it is better constrained, and it is also a more relevant value for projected warming over the next several decades. The first sentence here also describes it as an observational constraint, but it is not, it is a metric that can be produced from either data or models (or both), and climate models are routinely used to run TCR experiments. ECS is more widely-used than TCR which is why we focus more attention on it.
5	32	1	A more accurate title of this chapter would be "deficiencies in climate models" because the authors focus almost exclusively on processes and features that models have struggled to reproduce, rather than a balanced assessment that also indicates what these models do well. We changed the title to take this into account.
5	34	1	Scaffeta (2023) has been widely criticized in the scientific literature for its methods and conclusions. These results should not be presented without acknowledging these concerns, or better yet, the authors should attempt to survey the literature on this topic rather than presenting results from a single controversial paper. The reviewer is referring to an exchange regarding a different paper. We are unaware of any published critiques of the Scafetta paper we cite.
5	34	2	Spencer (2024) is not a peer reviewed journal paper and is not really appropriate to include here when there are many papers on this topic that have been peer reviewed. The reviewer should have provided references. We are unaware of any peer reviewed papers that present the comparison we show. We provide traceable accounts for the underlying data, all of which is from official sources.
5	35	1	The statement that the signal for anthropogenic greenhouse warming emerges first and most strongly is not supported and is inconsistent with my understanding of climate dynamics. The following sentence is also dubious (and probably backwards) since models run with observed surface temperatures tend to produce much better mid-tropospheric temperature simulations. The statement about early and strong emergence of the CO2 signal in the tropical troposphere is in the IPCC TAR and subsequent reports. Even models constrained with observed sea surface temperatures produce excess amplification aloft.
5	36	1	In most places the authors correctly describe the discrepancy between models and observations as a mismatch, which is appropriate because observations of mid-tropospheric temperatures are also subject to uncertainty (as indicated in the error bars in Figure 5.4). This is one of the reasons for the IPCC confidence assessment noted in the following paragraphs. However, here and in a few other places in this section the writing implies that differences can be solely attributed to model deficiencies. We don't take a position on the ultimate cause however we do note that the biases are pervasive across models and multiple observational data sets.
5	37	1	This section should be combined with the previous one as it is really just elaborating on the same discrepancy between climate models and observational estimates of tropospheric temperatures. One section discusses the discrepancy of trends and the other discusses the discrepancy of amplification rates, which is why the sections are separate.

5	39	1	There has indeed been considerable controversy about this particular metric. It is curious that the authors choose to cite two older papers here (2008 and 2009) rather than the rich recent literature, especially since they went to the trouble of updating on of their graphics with 2024 data. Recommend including a more balanced assessment of this discrepancy, it's potential causes, and recent efforts to address it, as well as noting that climate models are able to accurately capture many other aspects of climate change. Again, it is unfortunate that the reviewer did not provide any citations to this rich recent literature. We cited the key papers we are aware of.
5	39	1	This entire section is very misleading as it cherry-picks a specific result and takes it out of important context. The reason why stratospheric cooling has slowed (and, at least in one study, even warmed) in the past two decades is due to the recovery of the ozone layer. This is clearly stated in the Philipona et al article cited by the authors and in the IPCC report. Additionally, satellite-based estimates of stratospheric temperature (which is data the authors highlight in the previous section) do not show the same trends. This section should be removed or amended to note that stratospheric temperatures are influenced by multiple factors and that a comprehensive analysis of stratospheric temprature trends is fully consistent with those projected under climate warming scenarios. We have added a sentence discussing the ozone recovery issue and make reference to the recent Santer et al. study.
5	41	1	Many observational studies have shown that snow cover is decreasing, and have explained why it is more meaningful and useful to look at spring trends in snow cover, as well as why observations of snow cover can be uncertain. The issue here is model projections versus observations. Again, the reviewer provides no citations.
5	42	4	The authors provide a relatively accurate survey of results regarding hurricane numbers and landfall frequency, which have indeed not shown any trends. But their analysis of hurricane intensity, which has been shown in many studies to increase, is lacking...the chart showing just estimated windspeeds of the top ten landfalling storms is really weak given the analytical talents of the author team. They also do not provide any discussion of the physical basis for why hurricane numbers may not be changing while the intensity of the strongest hurricanes is expected to increase, nor analyze any data in the context of those conclusions. The challenge for global intensity metrics is that the satellite record prior to 1980-1990 (experts disagree on the data quality during this period) is inadequate, which is why we focus on the Atlantic hurricane data. Also there is no theory for hurricane number; that is a topic associated with substantial uncertainty.
6	47	5	Long term persistence is not a recognized property or phenomenon associated with rainfall data. The use of such a statistical technique, especially one that is not widely recognized or used in the hydroclimate community, demands additional justification. We have rewritten the text to remove specific reference to LTP.

6	53	4	The authors have cherry picked results throughout this section. For example, they have selected only a few quotes from IPCC and NCA describing extreme heat. The absolute single daily maximum temperature for a given year, for example, is a poor statistic for assessing statistical changes in extreme heat (it would be like comparing the tallest person in each country to try to calculate change in average height). A complete and comprehensive review of the underlying assessments and the data it cites clearly shows that extreme heat has been increasing in North America. The reviewer fails to identify any data or conclusion from the IPCC or NCA that differs from our assessment, and fails to cite any sources to justify this comment.
6	56	1	The "climate less prone to extremes" is a misleading statement. If minimum temperatures are increasing faster than maximum temperatures (which is an expectation of climate change based on basic physical principals), then the difference between warm and cold extremes on many timescales is expected to decrease. There are reasonable points to be made regarding observational deficiencies, regional variations in extreme events, and the potential benefits of reductions in extreme cold, rather than coming up with misleading statistics. But we show that extreme heat has also declined since the 1930s – Figures 6.3.1 and 6.3.3 refute the reviewer's statement.
6	58	3	The NCA5 heading is not a controversial statement, it simply says that things are changing, which they are by the author's own admissions and graphs. It does not suggest pervasive positive trends, as the authors suggest it does. We're not sure what sentence the reviewer is referring to.
6	61	3	The statistical techniques used in the 2019 paper are highly non-standard for evaluating precipitation statistics, and the 2024 results have not been peer reviewed. The results reported in the NCA and IPCC and the underlying studies have clearly demonstrated that extreme precipitation is increasing. The 2019 paper uses ordinary least squares to compute the trend, and a standard variance estimator from the econometrics literature to assess significance. As we point out, we also find evidence of increasing precipitation averages and extremes but only when selecting certain start dates.
6	61	7	The relevance of the paragraph on 19th century and paleoclimatic rainfall events is unclear. If anything, the fact that such extremes have occurred in the past argues for more aggressive adaptation measures to ensure that damages won't be as high if they happen again (even notwithstanding potential changes in risk due to climate change). Note, however, that additional context is provided in the box that follows two pages later. We agree that discovery of extreme events in the 19th century records indicates that disaster planning may need to encompass a wider range of risks.
6	62	1	The choice of looking at (only) 5-day precipitation totals is questionable. Most rainfall events, including the most extreme and damaging precipitation events, are typically on a daily timescale. Again, the reviewer provides no citations or evidence. Our results are robust to different day intervals, and we refer to 1- and 2-day results as well.
6	68	3	Perhaps this is more germane to the sea level rise section, but nuisance (high tide) flooding due to sea level rise has been observed across much of the United States. This is a topic we did not address.

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Saturday, July 19, 2025 11:05 AM
To: John Christy
Cc: Roy Spencer; Judith Curry; Ross McKittrick; Steven Koonin; Josh Loucks
Subject: Review of CWG Report

Team,

I have now sent the CWG report to a total of eight reviewers internal to the DOE enterprise (five people from the national labs and three from the Office of Science). I've asked for a quick review to conclude by the end of the day on Monday.

Two things as we move forward:

1) We should plan to hash out reviewers' comments on Tuesday. My suggestion is to have a virtual meeting (or more than one) focused on responding to comments and either implementing the suggested change or explaining why we chose not to implement the change. Is most of the team available for that?

2) As promised, you all have the ultimate pen on the report. No changes to the process there. However, let's think strategically about how we want to construct the "peer review report." For example, I've just reviewed the set of comments from the first lab reviewer, and it's my hunch that most comments will be rejected. If that's the case, we should treat our response to comments as an opening salvo in the long debate ahead.

If you're wondering why we would document and potentially publish the private back-and-forth between this author group and DOE peer reviewers, it's partly a CYA exercise from the Office of Science but I also suspect the peer review comments and your responses will be the subject of a future FOIA request. As with the CWG report itself, I think the peer review report should be as respectful as possible (even though I know some comments will make your blood boil—for example, our first reviewer is a fan of RCP8.5) and should help readers better understand the debate.

Finally, I'm sending this email to warn you that all the reviewer materials will be coming from my DOE account. If you don't see anything from me in the next hour or so, please check your spam filters. Also please keep in mind that my DOE emails (and your replies) will be easily discoverable by outside parties.

Best,
Travis

From: Judith Curry [curry.judith@gmail.com]
Sent: 6/10/2025 4:28:21 PM
To: Travis Fisher [travis.scott.fisher@gmail.com]
CC: Ross McKittrick [ross.mckittrick@gmail.com]; Steven Koonin [steven.koonin@gmail.com]; Josh Loucks [loucksj14@gmail.com]; seth.cohen@hq.doe.gov; Roy Spencer [roywspencer@hotmail.com]; John Christy [climateman60@gmail.com]
Subject: Revised Extreme Scenarios, with sea level rise
Attachments: Overemphasis on extreme scenarios (2).docx

See revised section on Extreme Scenarios, now including sea level rise

On Mon, Jun 9, 2025 at 7:41 PM Travis Fisher <travis.scott.fisher@gmail.com> wrote:
Ok, it looks like we'll lose someone at just about any time this week.

John, if we meet at noon ET on Friday, will you be able to join?

What works best for you, Judy?

On Mon, Jun 9, 2025 at 4:03 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:
I'm free this week except:
Wednesday 11:15 to 1 PM EDT
Thursday 8:30 to 10:00 AM
Friday 11:30 onwards

On Mon, Jun 9, 2025 at 3:52 PM Steven Koonin <steven.koonin@gmail.com> wrote:
Can't do Tuesday at 2 pm. But free any other time that day except 1330-1430.

Wednesday is good except 1200-1300 and 1500-1630.

Thursday doesn't work at all (at LLNL)

Friday I can make work anytime, but 1300-1500 wouldn't be optimal.

[All times above are EDT]

SEK

From: Josh Loucks <loucksj14@gmail.com>
Sent: Monday, June 9, 2025 2:49 PM
To: seth.cohen@hq.doe.gov; Steven Koonin <steven.koonin@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>; Judith Curry <curry.judith@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; John Christy <climateman60@gmail.com>
Subject: Meeting

Hi Everyone,

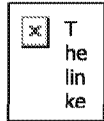
I wanted to put together another meeting/chat to help organize and keep everyone on the same page.

I know we discussed Tuesday on the call previously, but Wednesday could also work.

Would Tuesday at 2:00 pm EST work for everyone?

Please let me know if another time is better for everyone.

Thanks! - Josh



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<http://www.cfanclimate.net>

Overemphasis on extreme scenarios

To respond to the GCRA mandate to “project major trends for the subsequent 25 to 100 years,” projections of future climate change are driven by estimates of future emissions (SSP scenarios) and/or specified levels of radiative forcing (RCP scenarios). For the most part, NCA5 uses scenarios developed for the IPCC Assessment Reports.

NCA5 makes the following statements about future scenarios:

- “NCA5 authors were advised to assess the full range of scenarios available. (Front Matter)”
- “Scenarios of future emissions and land-use change are developed as plausible alternatives, but no relative likelihood is attached to them. Some recent studies, however, have argued that the highest scenario, SSP5-8.5, is no longer plausible without a reversal of current trends in the adoption of renewables and energy efficiency.” (Key Message 3.3 Traceable Analysis)

The NCA5 ignored a large body of literature (summarized in section xxx of the DOE Report) that shows the 8.5 and the 7.0 scenarios to be implausible, and advises against using them for policy making purposes. In 2021, UN Climate Negotiators (COP) stopped using scenarios above 4.5. The IPCC AR6 published in 2021 stated that “The likelihood of high-emission scenarios like RCP8.5 and SSP5-8.5 is considered low in light of recent energy sector developments.”

Even in the context of NCA5 being advised to assess the full range of scenarios available, a keyword search of the NCA5 of mentions of RCP/SSP scenarios finds over 50% referred to the extreme emissions scenarios RCP8.5/SSP5-8.5. Further, 10 figures only included the 8.5 scenarios: 5.2, 6.9, 7.4, 11.3, 14.6, 22.13, 22.19, 27.9, 29.13.

The problem is extreme for sea level rise projections. The sea level rise scenarios used in the NCA5 do not relate directly to the SSP emissions scenarios, but to specified amounts of sea level rise by 2100, whereby Low relates to 0.3 m (0.98 feet), Intermediate-Low relates to 0.5 m (1.64 feet), Intermediate relates to 1.0 m (3.28 feet), Intermediate-High relates to 1.5 m (4.92 feet), and High relates to 2.0 m (6.56 feet). (Table 4 of Guide to Using this Report).

Considering only projections representing processes in whose quantification there is at least medium confidence, the IPCC AR6 assessed global mean sea level projections for 2100 to fall between 0.2 and 1.6 m for the 5th—95th percentile range, for all scenarios ranging from RCP2.6 to RCP8.5. The IPCC AR6 cites values as high as 2.4 m at the upper end of the 95th percentile range for RCP8.5, if estimates include the hypothesized Marine Ice Cliff Instability (low confidence).

The range of sea level rise scenarios considered by the NCA5 includes Intermediate-High (1.5 m) and High (2.0 m) values that associated with the implausible extreme emissions scenario RCP8.5 and processes in which there is low confidence in understanding. The NCA5 neglects to include plausible lower scenarios, such as 0.2 m cited by the IPCC, that corresponds to the average rate of sea level rise over the past century.

With regards to actual predictions of sea level rise, Chapter 9 of the NCA states: “Under a range of potential global warming levels, average sea level along US coastlines is *likely* to be between 12 and 20

inches above 2000 sea levels in 2050 (Figure 9.2).” These values of sea level rise encompass the Intermediate scenario to values slightly higher than the High scenario from Table 4.

Global sea level rise projections to 2050 relative to a 2000 baseline can be evaluated with respect to the observed global sea level rise from 2000-2024, which is approximately 3.39 inches (0.28 feet).

<https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level>

Hence it is inferred that NCA5 is projecting values of sea level rise between 2025 and 2050 that are 3.5 to 5.8 times the rate observed during 2000-2024.

Chapter 9 further states: “Looking toward the future, an 11 inch 28 cm average rise along the contiguous US coastline is expected by 2050 (relative to 2020), with a *likely* range of 9-13 inches.” This analysis accounts for the observed sea level rise between 2000 and 2020.

With regards to confidence levels, NCA5 Chapter 9 Traceable Accounts states: “There is *high confidence* and it is *likely* that sea levels will rise about 11 inches (likely range of about 9–13 inches) between 2020 and 2050” Neither the statement nor the context in the paragraph does not distinguish as to whether this refers to global sea level rise, or US average sea level rise, although it is inferred to refer to global sea level rise.

In summary, the NCA5 presents future sea level rise scenarios that are not directly relatable either to SSP/RCP emissions scenarios or global warming levels. The NCA5 scenarios include two scenarios that are higher than the 95th percentile for the extreme emissions scenario RCP8.5 and include hypothesized ice sheet processes for which there is low confidence. Projections to 2050 require rates of sea level rise during 2025 through 2050 that are more than three times the rate observed during 2020-2024. Further, the NCA5 ascribes high confidence to these sea level rise projections.

The inclusion, and even the focus, on implausible extreme emissions scenarios supports projections of alarming impacts that are very unlikely to be driven by anthropogenic warming.

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Friday, April 18, 2025 4:39 PM
To: Roy W. Spencer; John Christy; Steven Koonin; Travis Fisher
Subject: revised table of contents
Attachments: Table.of.Contents.Apr18[RM].docx

Hi everyone

In the attached I have indicated in bold the sections that I think have been drafted thus far. I have also crossed a few out that I now think are not needed. We are not, after all, the IPCC, and we don't need to write a lot of background material.

Note that underlined titles are just section headings and no text is needed.

I'm next going to work on the Extreme Event Attribution section.

Ross

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Underline: Just a heading, not a section needing text

Bold: draft done

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From: Roy Spencer [roywspencer@hotmail.com]
Sent: 5/20/2025 12:15:20 PM
To: Ross McKittrick [ross.mckittrick@gmail.com]
CC: Steve Koonin [steven.koonin@gmail.com]; Judith Curry [curry.judith@gmail.com]; John Christy [climatemanager60@gmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]
Subject: Ross: Here's the corresponding ocean CO2 update graph and discussion....
Attachments: The uptake of extra CO2 from the atmosphere by ocean processes [RS].docx; Global_Carbon_Budget_2024_v1.0-1-with-some-correlations.xlsx

Also attached is the spreadsheet of data from the Global Carbon Project.

From: Roy Spencer <roywspencer@hotmail.com>
Sent: Tuesday, May 20, 2025 6:33 AM
To: Ross McKittrick <ross.mckittrick@gmail.com>
Cc: Steve Koonin <steven.koonin@gmail.com>; Judith Curry <curry.judith@gmail.com>; John Christy <climatemanager60@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>
Subject: Ross, please insert this comparison of the 20 vegetation models' CO2 uptake trends...

...into the carbon cycle chapter where appropriate. As Judy pointed out, there are large variations among models. I will do the ocean models next.

The uptake of extra CO₂ from the atmosphere by ocean processes has been modeled with 10 different dynamic global vegetation models, the outputs of which are updated every year by the Global Carbon Project (Friedlingstein, 2024). Like the results from the land models, all of the ocean models agree that the global oceans have been sequestering carbon from the atmosphere at an increasing rate during 1959-2023 (Fig. x.x.x2). Unlike the land models, however, the ocean models show much better agreement with each other, with the model producing the fastest increasing CO₂ uptake being only 65% faster than the model with the most slowly increasing CO₂ uptake. Note that the average trend in CO₂ uptake across all land models in Fig. x.x.x is 25% larger than the average trend in ocean uptake. This suggests land processes are increasing in their ability to remove CO₂ faster than ocean processes are increasing their CO₂ sequestration.

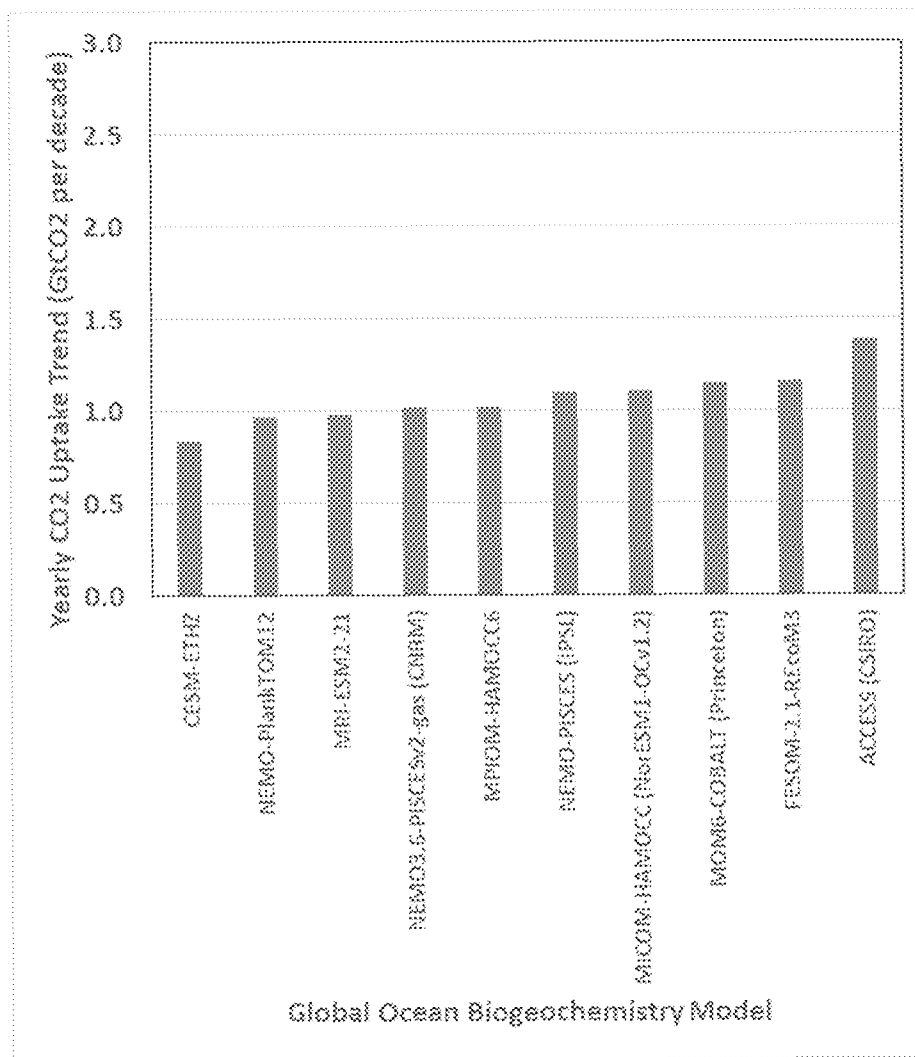


Fig. x.x.x2 Decadal trends in the yearly CO₂ uptake by ocean processes during 1959-2023 simulated by 10 different ocean biogeochemistry models periodically reported by the Global Carbon Project (Friedlingstein, 2024).

Friedlingstein, P., and 95 co-authors (2024): Global Carbon Budget 2024, Earth Syst. Sci. Data, <https://essd.copernicus.org/preprints/essd-2024-519>, 2024

Ocean CO₂ sink (positive values represent a flux from the atmosphere to the ocean)

All values in billion tonnes of carbon per year (GtC/yr), for the globe. For 1 billion tonnes C = 1 petagram of carbon (10¹⁵ gC) = 1 gigatonne C = 1 GtC

Methods: The ocean sink (uncertainty of ±0.4 GtC/yr on average) is estimated from the GCB

Prior to 1990, the GCB ocean sink estimate is calculated from the GCB

Note: the surface ocean fCO₂-products are adjusted for a pre-industrial

Cite individual estimates as:

Global ocean biogeochemical models:

(CNRM)	Berthet, S., Séférian, R., Bricaud, C., Chiffolleau, J., et al.
FESOM-2.1-REcoM3	Gürses, Ö., Oziel, L., Karakuş, O., Sidorenko, A., et al.
NEMO4.2-PISCES (IPSL)	Aumont, O., Ethé, Tagliabue, A., Bopp, L., et al.
MOM6-COBALT (Princeton)	Liao, E., Resplandy, L., Liu, J. and Bowman, K. W.
MRI-ESM2-3	Tsujino, H., Nakano, H., Sakamoto, K., et al.
OCv1.2)	Schwinger, J., Goris, N., Tjiputra, J. F., et al.
NEMO-PlankTOM12	Wright, R. M., Le Quéré, C., Buitenhuis, A., et al.
CESM-ETHZ	Doney, S. C., Lima, I., Feely, R. A., Glover, P. J., et al.
MPIOM-HAMOCC6	Lacroix F., Tatiana Ilyina, Moritz Mathis, et al.
ACCESS (CSIRO)	Law, R. M., Ziehn, T., Matear, R. J., Lenters, B. J.

fCO₂-products:

CMEMS-LSCE-FFNNv2	Chau, T. T. T., Gehlen, M., and Chevallier, P.
JMA-MLR	Iida, Y., Takatani, Y., Kojima, A., and Ishii, K.
LDEO-HPD	Gloege, L., Yan, M., Zheng, T., and McKee, D. L.
VLIZ-SOMFFN	Landschützer, P., Gruber, N., and Bakke, J. H. C.
NIES-ML3	Zeng J, Iida Y, Matsunaga T and Shirai T
OceanSODA-ETHZv2	Gregor, L., Shutler, J., & Gruber, N. (2021)
Jena-MLS	Rödenbeck, C., DeVries, T., Hauck, J., Lauer, A., et al.
CSIR-ML6	Gregor, L., Lebehof, A. D., Kok, S., and et al.
UEXP-FNN-U	Watson, A. J., Schuster, U., Shutler, J. C.

omitted

DECADAL TRENDS

0.277

0.317

1

2

GtC/yr

Individual models

year	GCB	NEMO3.6-PISCE	FESOM-2.1-REC
1959	1.008441074	0.565359441	1.130664336
1960	0.999830204	0.4594309	1.106798864
1961	0.879819334	0.31150236	0.957933392
1962	0.957408464	0.43957382	0.93506792
1963	1.132297595	0.66164528	1.034202448
1964	1.262686725	0.84771674	1.329336976
1965	1.362475855	0.998788199	1.208471503
1966	1.324364985	0.971859659	1.249606031
1967	1.160754116	0.728931119	1.192740559
1968	1.251043246	0.692002579	1.135875087
1969	1.365332376	0.902074038	1.172009615

1970	1.214321506	0.714145498	1.224144143
1971	1.292110637	0.701216958	1.278278671
1972	1.572099767	1.171288418	1.387413199
1973	1.461388897	0.859359878	1.414547727
1974	1.389078027	0.798431337	1.378682255
1975	1.307067157	0.736502797	1.207816783
1976	1.517156288	0.984574257	1.301951311
1977	1.625345418	1.076645717	1.468085839
1978	1.610334548	1.115717177	1.541220367
1979	1.577123678	1.281788636	1.382354895
1980	1.897112809	1.631860096	1.929489423
1981	1.816001939	1.327931556	1.877623951
1982	1.924991069	1.484003016	1.916758479
1983	2.120580199	1.660074476	2.119893007
1984	1.89846933	1.509145935	2.005027535
1985	1.81205846	1.246217395	1.774162063
1986	1.87864759	1.475288855	1.927296591
1987	1.98113672	1.748360315	1.873431119
1988	1.888125851	1.309431774	2.040565647
1989	1.863414981	1.431503234	1.839700175
1990	2.019161899	1.559574694	1.980834703
1991	2.176622749	1.856646154	2.096969231
1992	2.302731996	1.931717614	2.208103759
1993	2.25619622	1.982789073	2.260238287
1994	2.06764671	1.478860533	2.124372815
1995	2.073385512	1.617931993	2.184507343
1996	2.063902351	1.642003453	2.237641871
1997	2.208863456	1.915074913	2.151776399
1998	2.257103262	1.855146372	2.427910927
1999	2.052555657	1.464217832	2.277045455
2000	1.991930474	1.490289292	2.086179983
2001	1.886231644	1.270360752	1.89831451
2002	2.278784916	1.845432212	2.426449038
2003	2.395081829	1.880503671	2.439583566
2004	2.359740911	1.816575131	2.321718094
2005	2.391984274	1.868646591	2.407852622
2006	2.511929895	1.864718051	2.52798715
2007	2.444618704	1.85078951	2.620121678
2008	2.473544934	1.78286097	2.456256206
2009	2.612619855	2.04893243	2.428390734
2010	2.579939014	1.97200389	2.505525262
2011	2.616635608	1.93707535	2.74765979
2012	2.665729691	2.098146809	2.550794318
2013	2.711571187	2.022218269	2.710928846
2014	2.834165053	2.332289729	2.840063374
2015	2.88090858	2.436361189	2.785197902

2016	3.010809472	2.432432649	3.11133243
2017	2.830949198	2.024504108	2.793466958
2018	2.91976229	2.329575568	2.940601486
2019	2.930724243	2.277647028	2.923736014
2020	2.900425616	2.343718488	2.898870542
2021	2.800063925	2.006789948	2.78700507
2022	2.722721253	2.034861407	2.817139598
2023	2.880720693	2.221932867	2.876274126

cean)

values in billion tonnes of carbon dioxide per year (GtCO₂/yr), multiply the
3.664 billion tonnes of CO₂

estimated from the average of 10 global ocean biogeochemistry model
DBM multi-model mean with an offset applied. The offset is calculated
rial steady state source of CO₂ from rivers (of 0.65 GtC/yr) to be comp

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0.299

0.314

0.268

0.303

3

4

5

6

NEMO-PISCES (II MOM6-COBALT MRI-ESM2-21

MICOM-HAMOC

0.717795804	0.329608392	0.814036364	1.021184615
0.793388724	0.461113418	0.872950131	1.023277885
0.682981643	0.313618444	0.682863899	0.964371154
0.709574563	0.40612347	0.775777666	1.148464423
0.835167483	0.607628497	1.014691434	1.334557692
1.066760402	0.815133523	1.061605201	1.449650962
1.083353322	0.829638549	1.189518969	1.630744231
1.089946241	0.853143575	1.105432736	1.6358375
0.980539161	0.665648601	0.840346503	1.450930769
1.02213208	0.792153628	1.096260271	1.494024038
1.123725	0.939658654	1.230174038	1.593117308

1.00831792	0.81016368	0.964087806	1.483210577
0.999910839	0.878668706	1.124001573	1.537303846
1.196503759	1.130173733	1.480915341	1.798397115
1.275096678	1.111678759	1.102829108	1.846490385
1.217689598	0.987183785	1.090742876	1.803583654
1.126282517	0.873688811	1.041656643	1.749676923
1.206875437	1.044193837	1.410570411	1.918770192
1.290468357	1.155698864	1.499484178	2.018863462
1.323061276	1.18320389	1.394397946	1.903956731
1.225654196	1.090708916	1.422311713	1.79605
1.608247115	1.377213942	1.652225481	2.152143269
1.570840035	1.394718969	1.624139248	2.099236538
1.628432955	1.495223995	1.763053016	2.067329808
1.789025874	1.700729021	2.034966783	2.301423077
1.749618794	1.524234047	1.626880551	2.269516346
1.658211713	1.289739073	1.463794318	2.241609615
1.645804633	1.3542441	1.621708086	2.312702885
1.709397552	1.458749126	1.804621853	2.225796154
1.788990472	1.485254152	1.511535621	2.175889423
1.712583392	1.354759178	1.618449388	2.276982692
1.755176311	1.496264205	1.751363156	2.306075962
1.913769231	1.715769231	1.924276923	2.342169231
2.02036215	1.926274257	2.065190691	2.5532625
2.00195507	1.849779283	2.050104458	2.553355769
1.89954799	1.663284309	1.770018226	2.417449038
1.938140909	1.733789336	1.872931993	2.318542308
1.958733829	1.782294362	1.84884576	2.269635577
1.934326748	1.882799388	2.102759528	2.306728846
2.115919668	2.049304414	2.037673295	2.336822115
1.986512587	1.710809441	1.744587063	2.447915385
1.857105507	1.560314467	1.64950083	2.406008654
1.769698427	1.491819493	1.625414598	2.305101923
2.060291346	1.940324519	2.032328365	2.518195192
2.215884266	2.115829545	2.161242133	2.681288462
2.162477185	1.939334572	2.0711559	2.583381731
2.181070105	2.061839598	2.109069668	2.595475
2.239663024	2.173344624	2.287983435	2.741568269
2.268255944	2.14784965	2.024897203	2.617661538
2.240848864	2.067354677	2.23581097	2.787754808
2.195441783	2.132859703	2.174724738	2.643848077
2.240034703	2.185364729	2.184638505	2.652941346
2.285627622	2.228869755	2.259552273	2.824034615
2.395220542	2.240374781	2.38746604	2.944127885
2.438813462	2.270879808	2.310379808	2.962221154
2.488406381	2.310384834	2.472293575	3.007314423
2.526999301	2.26788986	2.555207343	3.121407692

2.74659222	2.449394886	2.55212111	3.111500962
2.53718514	2.309899913	2.419034878	3.026594231
2.606778059	2.295404939	2.466948645	3.0276875
2.574370979	2.417909965	2.428862413	3.022780769
2.614963899	2.442414991	2.38877618	2.945874038
2.549556818	2.245920017	2.299689948	3.100967308
2.478149738	2.273425044	2.309603715	3.114060577
2.435742657	2.43993007	2.730517483	3.329153846

numbers below by 3.664.

s and 8 fCO₂-products that reproduce the observed mean ocean sink of the as the half of the difference between GOBMs and data products in the period variable with the ocean model results and to satisfy the definition of the ocean

arsening algorithm in a global eddy-admitting ocean biogeochemical model. Jour biogeochemistry in the coupled ocean–sea ice–biogeochemistry model FESOM2. carbon and ecosystem studies.

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	0.265	0.229	0.279	0.378
	7	8	9	10
NEMO-PlankTOM12		CESM-ETHZ	MPIOM-HAM	ACCESS (CSIRO)
0.888243357		1.254454545	0.73483217	1.103422378
0.724004983		1.193484572	0.73578741	1.103255813
0.718766608		0.915514598	0.70574266	1.020089248
0.706528234		0.984544624	0.7476979	1.195922684
0.95228986		1.08557465	0.89965315	1.372756119
0.901051486		1.219604677	1.06260839	1.348589554
1.034813112		1.343634703	1.16356364	1.61742299
0.920574738		1.281664729	1.11051888	1.500256425
0.862336364		1.051694755	1.00547413	1.30408986
0.95809799		1.174724781	1.08542937	1.534923295
1.160859615		1.254754808	1.09638462	1.655756731

0.933621241	1.039784834	1.07233986	1.368590166
0.914382867	1.13781486	1.2162951	1.608423601
1.263144493	1.471844886	1.31325035	1.983257037
1.073906119	1.324874913	1.34820559	1.732090472
0.911667745	1.134904939	1.35516084	1.687923907
0.747429371	1.067934965	1.41111608	1.583757343
1.180190997	1.289964991	1.40707133	1.902590778
1.324952622	1.428995017	1.54902657	1.916424213
1.239714248	1.450025044	1.50998182	1.917257649
1.316475874	1.38905507	1.24493706	2.097091084
1.5142375	1.700085096	1.61389231	2.266924519
1.390999126	1.561115122	1.60884755	2.179757955
1.632760752	1.700145149	1.6008028	2.43659139
1.833522378	1.933175175	1.72275804	2.585424825
1.574284003	1.626205201	1.73171329	1.84325826
1.445045629	1.558235227	1.71466853	2.204091696
1.377807255	1.543265253	1.72262378	2.280925131
1.525568881	1.72429528	1.66557902	2.550758566
1.451330507	1.725325306	1.68953427	2.178592002
1.485092133	1.541355332	1.79048951	2.058425437
1.598853759	1.708385358	1.83144476	2.218258872
1.834615385	1.872415385	1.8164	2.417092308
2.00837701	2.055445411	2.10035524	2.556925743
1.953138636	1.987475437	2.03631049	2.459759178
1.761900262	1.777505463	1.90226573	2.233592614
1.637661888	1.81253549	1.89022098	2.386426049
1.691423514	1.810565516	1.84317622	2.278259484
1.82718514	1.972595542	1.75313147	2.75909292
1.880946766	2.003625568	1.78908671	2.729926355
1.619708392	1.725655594	1.93104196	2.29275979
1.465470017	1.615685621	1.9419972	2.267593226
1.528231643	1.587715647	1.80795245	2.267426661
1.962993269	2.025745673	2.07790769	2.712260096
1.949754895	2.178775699	2.11686294	2.841093531
2.005516521	2.071805726	2.10381818	2.863926967
1.947278147	2.155835752	2.10677343	2.904760402
2.129039773	2.179865778	2.17972867	3.302593837
2.014801399	2.078895804	2.17968392	3.144427273
2.056563024	2.04392583	2.21663916	3.229260708
2.16032465	2.146955857	2.15759441	3.205094143
2.010086276	2.144985883	2.21854965	3.153927579
2.168847902	2.150015909	2.3055049	3.173761014
2.133609528	2.316045935	2.34446014	3.313594449
2.188371154	2.328075962	2.42641538	3.268427885
2.33313278	2.365105988	2.50837063	3.40726132
2.447894406	2.493136014	2.54132587	3.542094755

2.461656031	2.59416604	2.55528112	3.421928191
2.324417657	2.348196066	2.43023636	3.327761626
2.344179283	2.427226093	2.48919161	3.522595061
2.343940909	2.415256119	2.43214685	3.449428497
2.287702535	2.429286145	2.6001021	3.450261932
2.183464161	2.237316171	2.65705734	3.329095367
2.188225787	2.287346198	2.59501259	3.321928802
2.517987413	2.436376224	2.55796783	3.595762238

1990s. UExP-FFN-U not used for the fCO₂-products average. Cite as: Friedlingstein et al. 1990-2001 (inclusive). This ensures no artificial jumps occur in 1990 when the data from the Global Carbon Project carbon sink used in the Global Carbon Project

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6.723772578

1

Multi-model mean		Model Spread (sd)	fCO ₂ -products
0.85596014		0.283010204	CMEMS-LSCE-
0.84734927		0.261289234	
0.7273384		0.253649164	
0.804927531		0.265731944	
0.979816661		0.250214528	
1.110205791		0.220671988	
1.209994921		0.25808497	
1.171884052		0.249628748	
1.008273182		0.250569223	
1.098562312		0.266441682	
1.212851442		0.244930678	

1.061840573	0.238439541	
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1.308907963	0.302005833	
1.236597094	0.325091911	
1.154586224	0.34115788	
1.364675354	0.319011381	
1.472864484	0.301117615	
1.457853615	0.275289525	
1.424642745	0.29975917	
1.744631875	0.282850457	
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1.772510135	0.295136835	
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1.745988396	0.239013623	
1.659577526	0.342165631	
1.726166656	0.344107609	
1.828655787	0.328055382	
1.735644917	0.30974636	
1.710934047	0.290082533	
1.820623177	0.271575177	1.905596564
1.979012308	0.232830416	2.039494126
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2.113490568	0.232271883	2.179659657
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1.939268829	0.271468167	2.187699805
1.936257959	0.240781415	2.150976882
2.060547089	0.295157589	2.309210968
2.122636219	0.293616215	2.181567485
1.92002535	0.326578965	2.061701016
1.83401448	0.333590779	2.101306663
1.75520361	0.331510239	2.098720593
2.16019274	0.286999192	2.331509101
2.258081871	0.306812765	2.428415435
2.193971001	0.316001191	2.42675603
2.233860131	0.31567307	2.50629162
2.362649261	0.405562368	2.592227083
2.294738392	0.38908691	2.589900396
2.311727522	0.419713017	2.617725746
2.329416652	0.353720837	2.834294527
2.326805782	0.356082909	2.799403525
2.408094913	0.380053735	2.715493282
2.472384043	0.379904484	2.804980936
2.492673173	0.380152035	2.852720914
2.606462303	0.364216929	3.000016196
2.671751434	0.383642347	3.143797323

2.743640564	0.347698652	3.19289527
2.554129694	0.387043845	2.969548042
2.645018824	0.397362186	2.941707245
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2.640197085	0.361749661	3.016355068
2.539686215	0.429397552	2.957292099
2.541975345	0.420511074	2.850959932
2.714164476	0.436785966	2.811183298

et al 2024 (see summary tab).
 ta products are used to estimate the sink in conjunction with the GOBMs.

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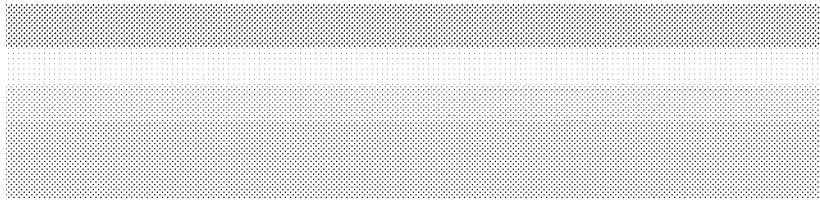
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/doi.org/10.5194/gmd-12-5113-2019, 2019.
 , 2020.

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JMA-MLR		LDEO-HPD	VLIZ-SOM	NIES-	OceanSC	Jena-MLS	CSIR-ML6
		1.102975815				0.6772095	
		1.105233526				0.7578295	
		1.024491035				0.5587139	
		1.051491884				0.6233977	
		1.316824735				0.8620396	
		1.439915864				0.919434	
		1.504523787				1.012942	
		1.413104604				0.9133525	
		1.247585962				0.7363462	
		1.40667768				0.8550335	
		1.505320371				1.0051094	

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	1.62317428				1.1218663	
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	1.460029955				0.9657691	
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	2.516311602				1.8123156	
	2.456637715				1.8138298	
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	2.151272869				1.7783088	
	2.431488112				1.6499037	
3.089945718	2.447780402	2.27573	2.27	2.2128	1.7385264	1.7972763
3.079310739	2.860011527	2.30934	2.36	2.2656	2.1187421	1.96535649
2.950946226	3.158164971	2.38808	2.3	2.3256	2.5037371	2.00513814
2.836666826	2.944623605	2.4568	2.26	2.3804	2.2110625	1.92492074
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2.742901935	2.035349656	2.11061	2.31	2.3427	1.9119511	1.93080099
2.778371278	2.384026623	2.29732	2.33	2.4523	2.2784572	2.03194636
2.849589332	2.357653084	2.13863	2.5	2.4569	2.6699735	1.98275578
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3.660992219	2.667382771	2.68298	2.81	2.9149	2.9819826	3.80323955
3.450510277	2.376838658	2.38188	2.77	2.7878	2.7421776	3.86699399
3.607509637	2.345491633	2.50283	3.07	2.9805	3.0414161	4.01516163



id-10-2567-2017, 2017.

UoEX-

Average fCO2-products (excl. UExP-FFN-U)

2.7702347	2.770234728
2.8431536	2.84315362
2.8498427	2.849842691
2.6448053	2.644805336
2.6091285	2.609128499
2.5710612	2.571061158
2.5200439	2.520043874
2.6401047	2.640104675
2.6428743	2.642874265
2.3545708	2.35457077
2.3693632	2.369363213
2.3480535	2.348053479
2.5677037	2.567703748
2.7233755	2.723375463
2.7542564	2.754256392
2.9448463	2.944846296
3.1047732	3.104773188
3.1126682	3.11266818
3.1184782	3.118478203
3.4264406	3.42644062
3.477075	3.477075005
3.5561306	3.556130552
3.6043574	3.604357386
3.6202599	3.620259905
3.6496235	3.649623537
3.7558328	3.755832815

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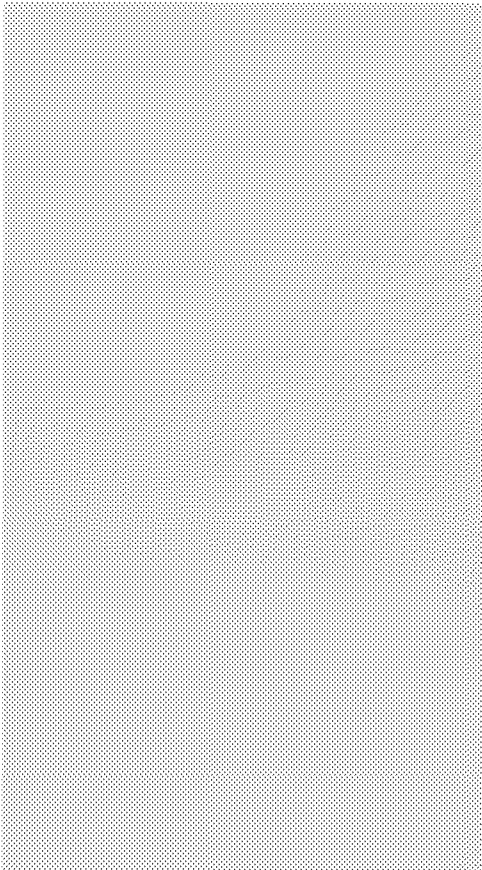
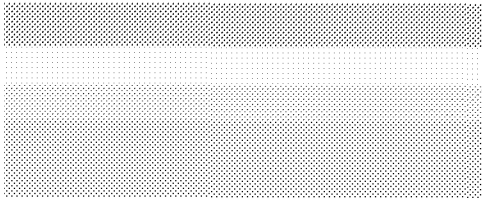
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3.232840531
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3.04727691

	1.214
	1.292
	1.572
	1.461
	1.389
	1.307
	1.517
	1.625
	1.610
	1.577
	1.897
	1.816
	1.925
	2.121
	1.898
	1.812
	1.879
	1.981
	1.888
	1.863
0.434918549	2.019
0.39532229	2.177
0.403349915	2.303
0.342525995	2.256
0.269560096	2.068
0.288544425	2.073
0.272277912	2.064
0.209080595	2.209
0.287530468	2.257
0.297104482	2.053
0.22094272	1.992
0.310994826	1.886
0.144893734	2.279
0.199646709	2.395
0.14693051	2.360
0.126521783	2.392
0.121506676	2.512
0.194651647	2.445
0.137393709	2.474
0.148622274	2.613
0.131235906	2.580
0.177979422	2.617
0.173430101	2.666
0.201475638	2.712
0.243408703	2.834
0.213753221	2.881

0.219452814	3.011
0.224854509	2.831
0.255696133	2.920
0.300975145	2.931
0.364071895	2.900
0.432222342	2.800
0.512255249	2.723
0.547792708	2.881

0.434918549
0.39532229
0.403349915
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average of best from
regressions

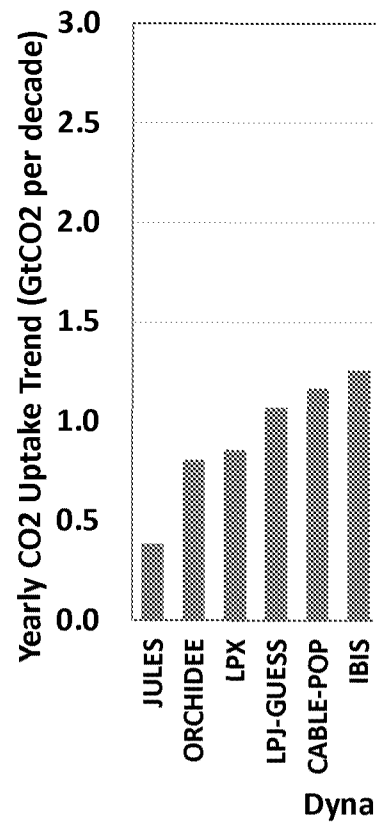
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1.2181535

1.6488552

GTCO2/yr DECADAL TRENDS

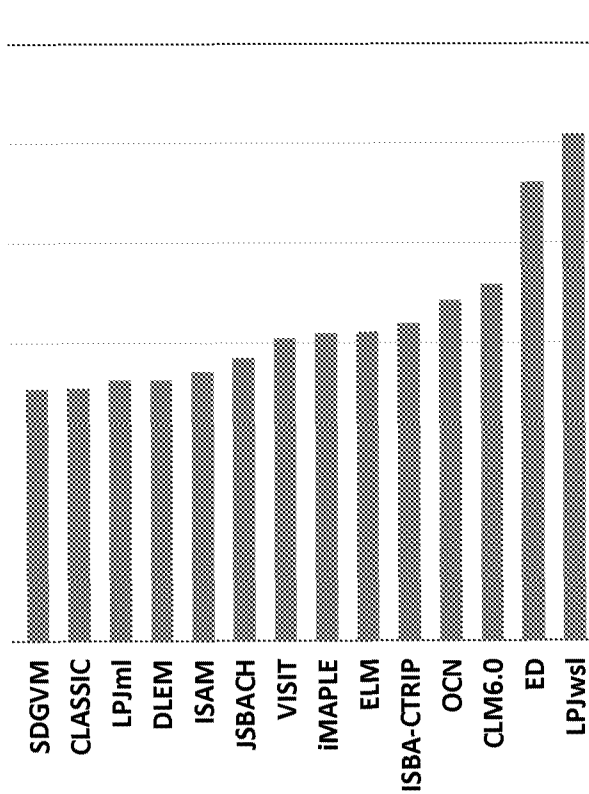
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1.0212455	0.2787242	MPIOM-HAM
1.0951148	0.2988851	NEMO-PISC
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1.1508835	0.3141058	MOM6-COB
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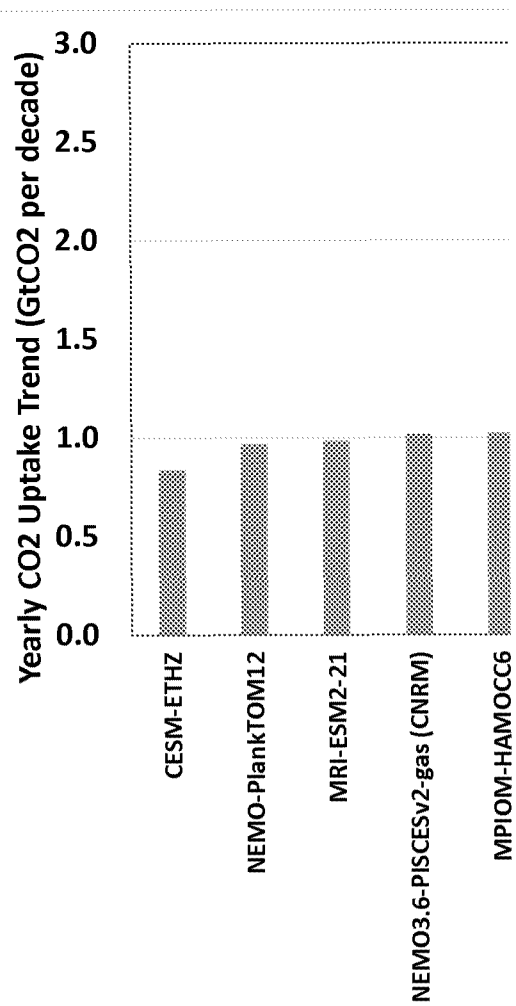


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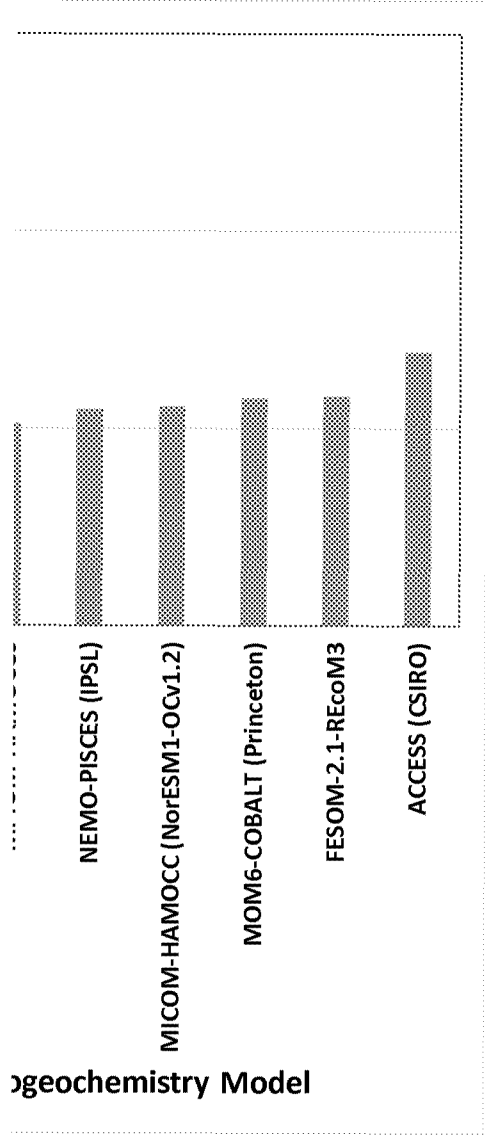


Global Vegetation Model



Global Ocean Biogeochemistry Model

Z
 kTOM12
 21
 ISCESv2-gas (CNRM)
 MOCC6
 CES (IPSL)
 MOCC (NorESM1-OCv1.2)
 ALT (Princeton)
 REcoM3
 SIRO)



From: Roy Spencer <roywspencer@hotmail.com>
Sent: Tuesday, May 20, 2025 7:34 AM
To: Ross McKittrick
Cc: Steve Koonin; Judith Curry; John Christy; Travis Fisher
Subject: Ross, please insert this comparison of the 20 vegetation models' CO2 uptake trends...
Attachments: The uptake of extra CO2 from the atmosphere by land surface processes [RS].docx

...into the carbon cycle chapter where appropriate. As Judy pointed out, there are large variations among models. I will do the ocean models next.

The uptake of extra CO₂ from the atmosphere by land surface processes (as also inferred from global greening) has been modeled with 20 different dynamic global vegetation models, the outputs of which are updated every year by the Global Carbon Project (Friedlingstein, 2024). As seen in Fig. x.x.x, all of those models agree that vegetation and soils have been sequestering carbon from the atmosphere. But we also see that the long-term trends over 1959 to 2023 (65 years) vary widely between models, by nearly a factor of 7. This demonstrates that there remains considerable uncertainty regarding how fast CO₂ from the atmosphere is being removed by land processes, which in turn translates into uncertainty regarding future atmospheric CO₂ concentrations. Those uncertain future CO₂ concentrations then imply a source of uncertainty in climate model simulations of future climate change.

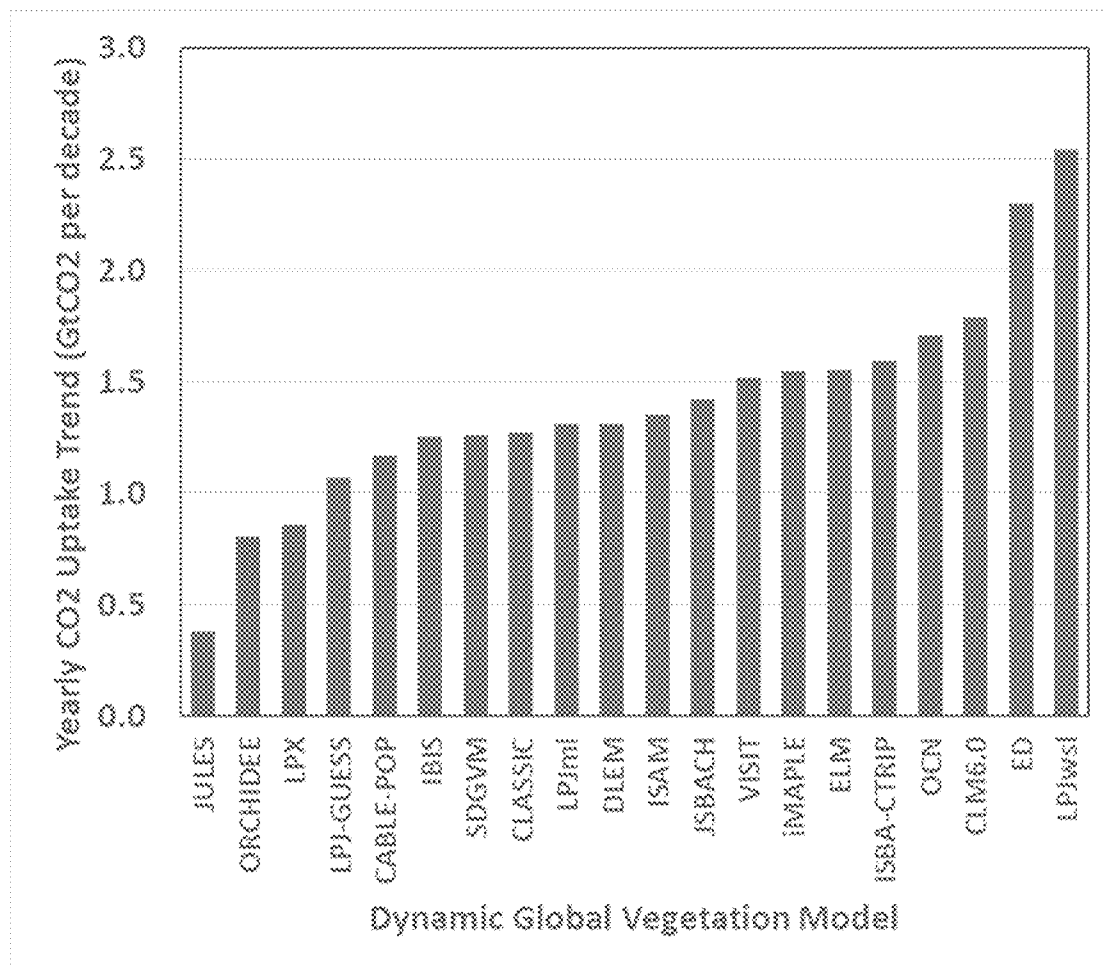


Fig. x.x.x Decadal trends in the yearly CO₂ uptake by land processes during 1959-2023 simulated by 20 different dynamic global vegetation models periodically reported by the Global Carbon Project (Friedlingstein, 2024).

Friedlingstein, P., and 95 co-authors (2024): Global Carbon Budget 2024, Earth Syst. Sci. Data, <https://essd.copernicus.org/preprints/essd-2024-519>, 2024

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Monday, June 2, 2025 10:33 AM
To: Travis Fisher; Josh Loucks; John Christy; Roy W. Spencer; Judith Curry; Steven Koonin
Subject: Scoping
Attachments: USGCRP review.docx

I have drafted a 1-page charge letter for the Secretary, setting out what I think are entirely defensible questions for a cabinet official to ask, and which would be feasible for us to answer on a short time scale. Comments welcome.

Draft Charge letter.

The United States Congress passed the GCRA in 1990, some 35 years ago, thus creating the U.S. Global Change Research Program. By titling it “Global Change” the governing legislation created vague and open-ended guidance as to the mandate of the agency and the required work products. Since 1990 the U.S. government has spent some \$X billion and the agency has produced a long list of reports, especially five National Climate Assessments. In light of President Trump’s recent Executive Order on Restoring Gold Standard Science I am initiating a review of the current status of NCA work products. As a cabinet official charged with key decision-making responsibility I am struck by the fact that, while USGCRP documents receive considerable media attention upon release and are popular with environmental activists, little reliance is placed on them within the energy industry and even within government agencies for critical decision-making purposes.

Thus, I wish to assess whether the USGCRP has yielded sufficient public value to merit its continuation. In raising this question I am speaking mainly of the public-facing summary documents. It is of little use to decision-makers if important information is buried deep in a thousand-page report while summaries present a slanted and distracting focused elsewhere.

Therefore, as a contribution to Administration efforts to achieve Gold Standard Science, improve government efficiency and ensure money is spent in ways that yield tangible benefits to the U.S. public, I request the Climate Working Group prepare a short analysis addressing the following questions.

1. Does the Fifth National Climate Assessment meet the standards of President Trump’s Executive Order on Gold Standard Science?
2. Focusing specifically on the public-facing summary material at <https://nca2023.globalchange.gov/>:
 - a. Does this material provide a scientifically rigorous and balanced summary of climate science, including its limitations and uncertainties?
 - b. Does this material, including the choice of which topics to highlight and which to ignore, provide reliable guidance for policymakers charged with making long term energy and economic planning decisions?
 - c. Does this material provide a scientifically rigorous and balanced summary of trends and changes in U.S. climatic conditions including temperatures, precipitation and weather extremes?
3. Does the work of the NCA process overlap with work done by or responsibilities held by other agencies and levels of government, and to the extent it does are there potential advantages to having the work done by those other agencies and levels of government?
4. If the USGCRP had not been created in 1990 would you recommend its creation today?

From: Roy Spencer [roywspencer@hotmail.com]
Sent: 4/17/2025 11:17:32 AM
To: Ross McKittrick [ross.mckittrick@gmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]
CC: Steven Koonin [steven.koonin@gmail.com]; John Christy [climatemanager60@gmail.com]
Subject: Section 1.4.2 Can climate models reproduce the recent past?
Attachments: 1.4.2 Can climate models reproduce the recent past [RS].docx

Attached. This is the minimum I think needs to be in this section. Of course, more could be added, but I think we need to stick to our strongest arguments, given the limited time available.

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Cc: Steven Koonin <steven.koonin@gmail.com>; John Christy <climatemanager60@gmail.com>
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Best,
Travis

<DE.memo.outline.Apr.11.[RM].docx>

Climate models are the primary tool used to project future climate changes in response to increasing atmospheric levels of anthropogenic greenhouse gases. They provide the theoretical evidence underpinning energy policy changes, such as efforts to reduce carbon dioxide emissions. In order to determine the value of climate models for this purpose, it is reasonable to ask how well they have reproduced climate variations over the recent past, say the last half-century.

Computerized climate models are complex representations of the time-dependent behavior of the global atmosphere and ocean. They are extensions of weather forecast models that have been the basis for our daily weather forecasts since the late 1970s. But while weather forecast models take an initial state of the atmosphere and then project forward in time the evolving state of the atmosphere over several days, climate models instead are used to see how the average state of the atmosphere and ocean are altered over long periods of time (years, decades, or centuries) in response to anthropogenic forcing agents.

Of great concern is the fact that, after several decades of the climate modeling enterprise involving approximately two dozen models operated by research centers around the world, the range of future warming they produce in response to a hypothetical doubling of atmospheric CO₂ (2XCO₂) extends over a factor of three. This range of disagreement between models has not changed for decades.

One might then reasonably ask: If climate models are based upon known physical principles (as is often claimed) and those models represent “settled” science, why do different climate modeling groups obtain results that vary over such wide ranges?

Problems with climate models are not just in their disagreement over the future, but also in their ability to replicate the recent past. This is illustrated in Fig. X1 with results from the latest (sixth) Climate Model Intercomparison Project (CMIP6, ref.) showing the linear warming trends for 1979 through 2023 as produced by models versus observations. To provide a fair test of the claims of the IPCC, only those models whose warming response to 2XCO₂ fall within the “highly likely” range of 2 to 5 deg. C of eventual future warming are shown.

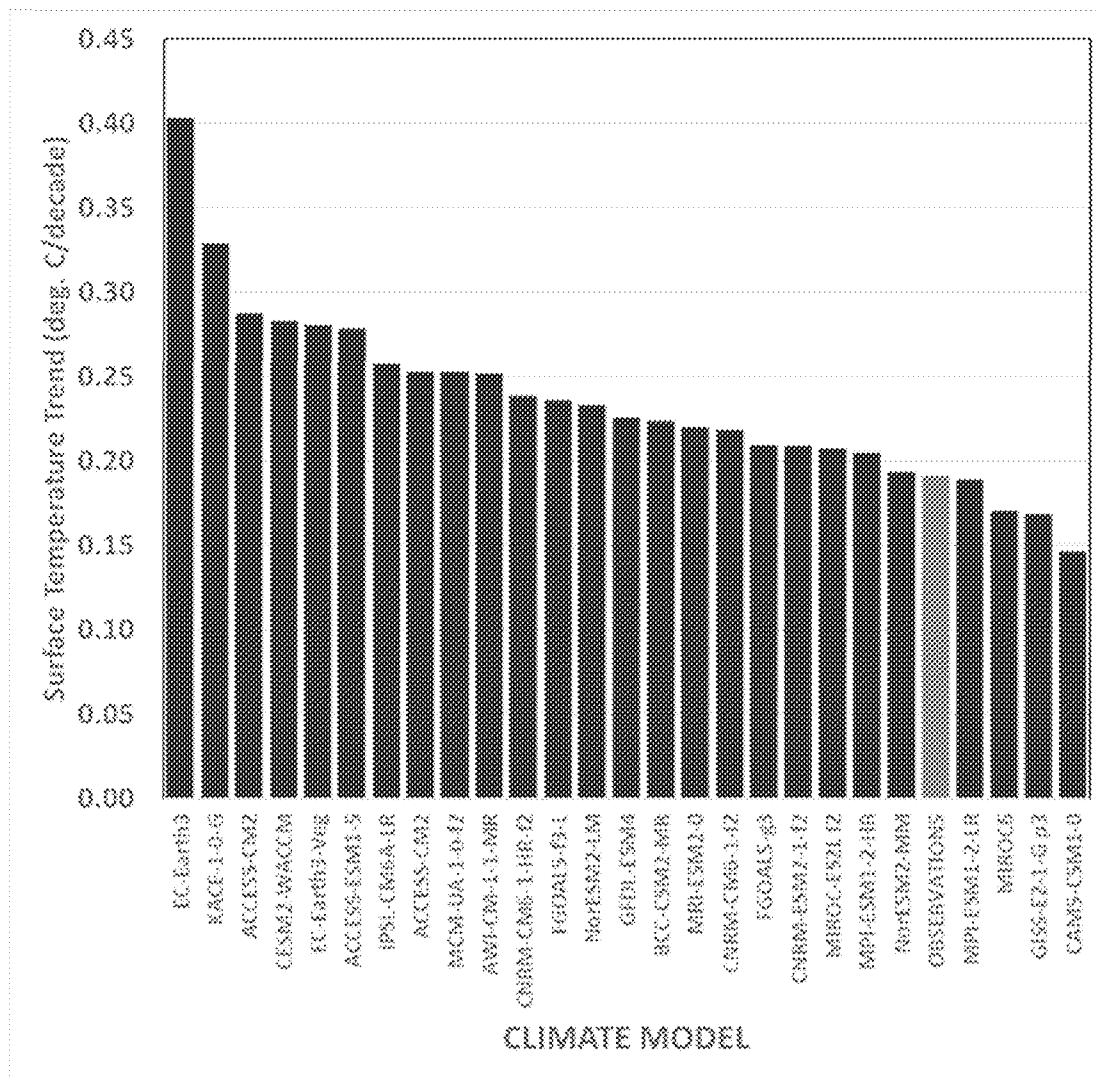


Fig. X1. The linear global-average surface warming trends 1979-2023 produced by those climate models the IPCC deems as most plausible (red bars) are almost all warmer than the observed warming trends (blue bar, the average of 5 widely used surface temperature datasets). [Data source: <https://climexp.knmi.nl/start.cgi> (accessed January 10, 2024)]

There are several reasons why 1979 was chosen as the starting date for comparison. First, we have had global satellite observations only since 1979 which provide important input into “reanalysis” models which take all available types of weather data to estimate conditions in regions where little to no conventional data had previously existed. Second, warming has been greatest since the 1970s. Third, the assumed radiative forcing of the climate system from increasing greenhouse gases has also been the greatest since the 1970s. And finally, the period since 1979 (~45 years) is sufficiently long to average out the noise caused by internal climate fluctuations such as El Nino, La Nina, and major volcanic eruptions.

In summary, the period since 1979 provides a robust test of climate models to see if the anticipated strong warming response to anthropogenic forcing has indeed been occurring. The results in Fig. X1 show that the climate models used to support energy policy decisions have, on average, been running too warm when compared to surface temperature observations.

The disparity between models and observations becomes somewhat worse when we examine the region of the atmosphere where the models project the greatest warming: the tropical mid- to upper-troposphere. This is where a “hot spot” has been expected to develop in response to anthropogenic global warming. As shown in Fig. X2, the average response of climate models has been to warm the tropical troposphere much too fast.

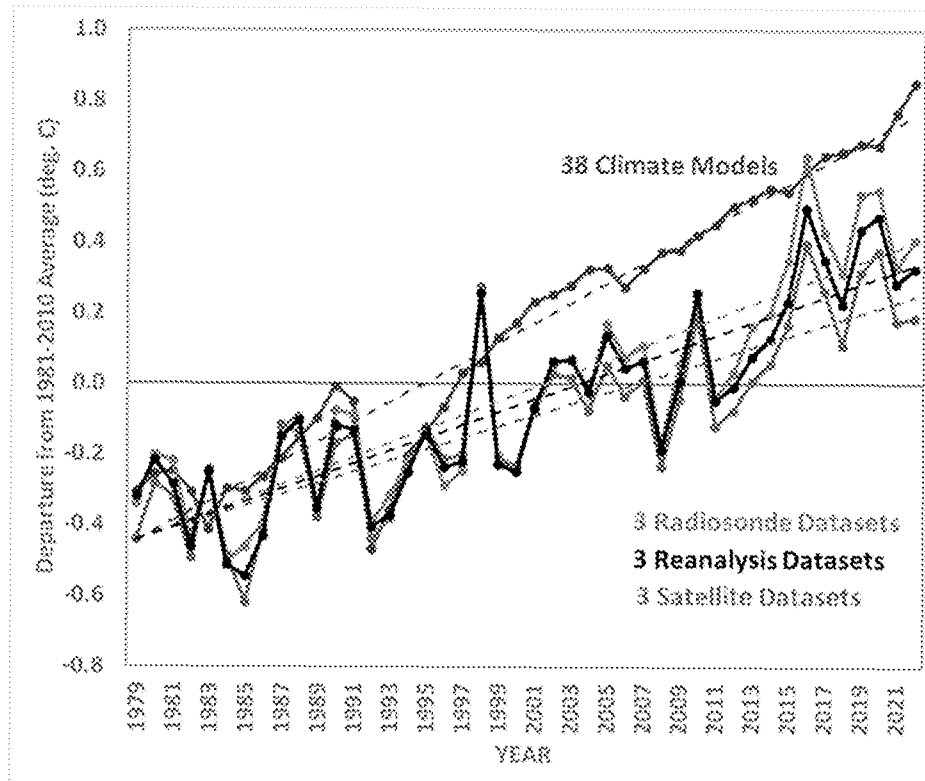


Fig. X2. Yearly global-average lower tropospheric temperatures (1979-2022) from the average of 38 climate models compared to those measured by the averages of 3 satellite datasets (blue), 3 reanalysis datasets (black), and 3 radiosonde (weather balloon) datasets (green). [Calculations based upon data from McKittrick & Christy (2020) and Blunden et al. (2023). Time series have been adjusted so their trend lines start at the same time, in 1979; this method of plotting can be shown to provide the earliest evidence of differences in datasets having different linear trends.

As demonstrated in Fig. X2, the models have diverged from the observations since approximately 2000. While the reasons for this are not clear, it is well known that the climate system we live in includes complex interactions between clouds, precipitation, water vapor, and radiation (both sunlight and infrared). Some of those processes are not even understood, let alone included in climate models. For example, the cloud and precipitation processes controlling the most abundant greenhouse gas in the atmosphere — water vapor — are still only poorly understood, especially when it comes to how those processes might change in response to warming.

An even larger discrepancy between models and observations exists when we test them in a region of particular importance to global food production: the U.S. Corn Belt. Fig. X.3 shows the warming trends for summertime (June, July, August) for the Corn Belt during 1973 to 2022.

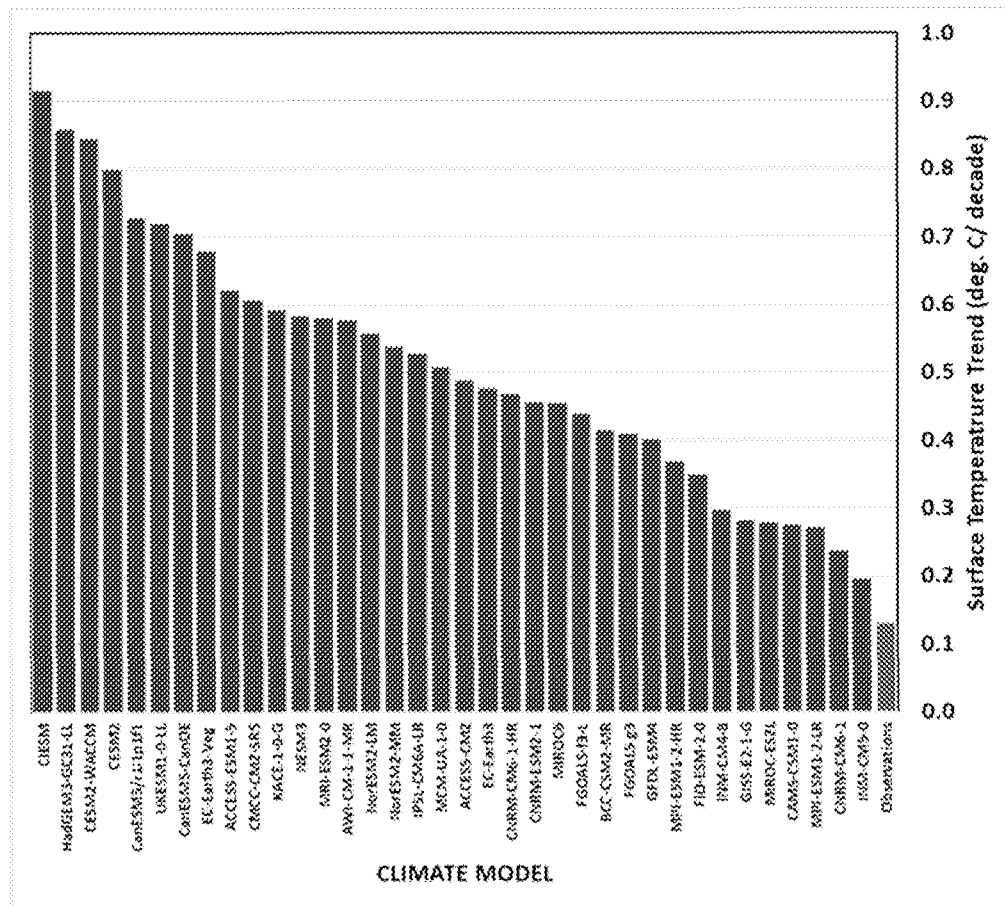


Fig. X3. As in Fig. X1, but for the U.S. 12-state Corn Belt (IN, IA, NE, ND, SD, MO, MN, WI, MI, OH, KS, NE) in summer during 1973-2022, showing that all 36 climate models (red) produced too much warming compared to observations (blue).

As discussed in Chapter 3, the anticipated negative effects of increasing temperatures on U.S. corn yields have not materialized, which is in contrast to widely publicized studies proclaiming that theoretical future impacts are already being experienced (e.g. Seager et al., 2017).

Given these rather large discrepancies between models and observations for the recent past, it is clear that global climate models are of questionable value for projecting future climate change.

From: Roy Spencer <roywspencer@hotmail.com>
Sent: Friday, April 18, 2025 7:34 AM
To: Ross McKittrick; Travis Fisher
Cc: Steven Koonin; John Christy
Subject: Section 1.4.3 attached
Attachments: 1.4.3 The carbon cycle, emissions scenarios, and global greening [RS].docx

Ross:

I think we should combine sections 1.4.3 and 1.4.4 (attached) which I now call "The carbon cycle, emissions scenarios, and global greening".

I found that all of these need to be discussed together. Feel free to reword the section title.

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In addition to the uncertain sensitivity of the climate system to increasing CO₂, future climate projections also depend upon uncertain estimates of how much “extra” CO₂ will accumulate in the atmosphere in the future. These uncertain estimates are a function of two components: (1) future rates of global anthropogenic CO₂ emissions, and (2) how fast the land and ocean remove extra CO₂ from the atmosphere.

Global carbon cycle models are used to quantify the second component, using estimates of various land and ocean processes that remove CO₂ from, and emit CO₂ into, the atmosphere. Our understanding of these processes was reviewed by Crisp et al. (2021). The natural fluxes of CO₂ in and out of the Earth’s surface are very large, many times anthropogenic emissions, but those CO₂ sources and sinks were assumed to be in approximate balance in pre-Industrial times, as evidenced by relatively constant levels of atmospheric CO₂ in centuries past derived from air bubbles in ice cores. This is one of the reasons why increasing atmospheric CO₂ levels are believed to be dominated by anthropogenic sources.

Specifically, fossil fuel burning (and to a lesser extent land use [biomass burning] and cement production) has led to steadily increasing CO₂ levels in the atmosphere, as shown in Fig. X1.

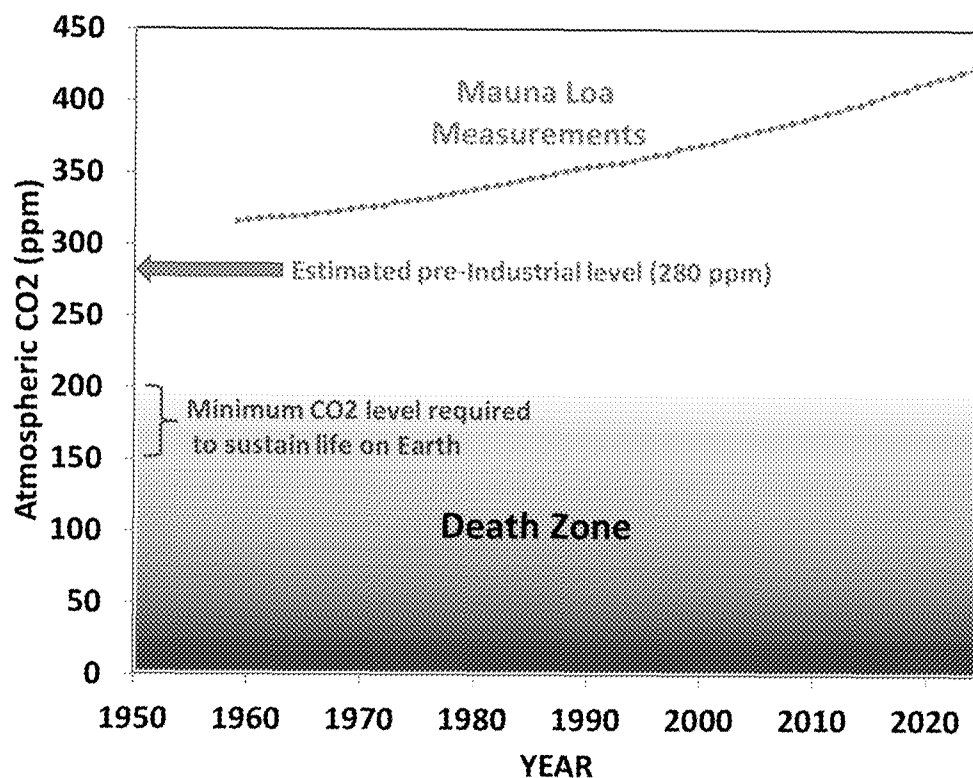


Fig. X1. Yearly average atmospheric CO₂ concentrations (1959-2024) measured at Mauna Loa, HI (green) compared to the estimated pre-Industrial CO₂ concentration of 280 ppm, and the estimated minimum levels required to sustain life on Earth (150 to 200 ppm).

As noted in Fig. X1, life on Earth requires CO₂ levels of at least 150 to 200 ppm. This is because the food chains on land and in the ocean begin with vegetation and biota that depend upon photosynthesis, which requires CO₂.

Life on Earth has benefitted from more CO₂ in the atmosphere. Since routine monitoring of atmospheric CO₂ levels began in 1958 at Mauna Loa, Hawaii, it has been calculated that each year natural processes remove a net amount of CO₂ equivalent to about 50% of global emissions. Thus, anthropogenic CO₂ emissions average twice what is required to explain the atmospheric rise in CO₂ concentration. The near-constancy of that 50% fraction also means that the more CO₂ humanity produces, the faster Nature removes CO₂ from the atmosphere. That 50% fraction changes somewhat from year to year due to natural carbon cycle imbalances from El Nino, La Nina, and varying weather patterns. There was also a substantial additional reduction in atmospheric CO₂ after the 1991 eruption of Mt. Pinatubo, a curious result that has yet to be explained (Angert et al., 2004).

Another consequence of the rapid rate of removal of CO₂ from the atmosphere is that “Net Zero” emissions are not required to halt the rise in atmospheric CO₂. If global emissions were to suddenly be reduced by 50%, the natural rate of CO₂ removal would approximately match anthropogenic emissions, and CO₂ levels would stop rising.

The main processes which remove excess CO₂ from the atmosphere are increased production of land vegetation (especially at high latitudes), some increase in the sequestering of carbon in soils, and uptake of CO₂ by the ocean due to the increasing partial pressure of atmospheric CO₂ over that of CO₂ dissolved in the ocean. All twenty land carbon cycle models tracked by the Global Carbon Project (Friedlingstein et al., 2024) show land processes have been removing excess CO₂ at an increasing rate since 1959. This is consistent with a “global greening” phenomenon observed by satellites since monitoring of global greenness began in the 1982. This greening has been traced to CO₂ fertilization and greater drought tolerance of plants exposed to elevated CO₂ levels. While there had been some uncertainty whether a greening trend continued beyond 2000, the most recent research (Chen et al., 2023) has shown continued greening, with even some slight acceleration since 2000.

While land vegetation has been responding positively to more atmospheric CO₂, uptake of extra CO₂ by ocean biological processes remains too uncertain to be reliably measured. Our current understanding of these and many more carbon cycle processes was reviewed by Crisp et al. (2021).

When the two components required to estimate future atmospheric CO₂ concentrations are combined (anthropogenic emissions estimates along with carbon cycle model estimates of atmospheric CO₂ removal), we get estimates of future CO₂ concentrations required by climate models to estimate future rates of warming. Because the largest uncertainty lies in future global rate of anthropogenic CO₂ emissions, the IPCC has used a wide variety of possible emissions scenarios, and the four most common ones from the CMIP6 climate model experiments are shown in Fig. X2.

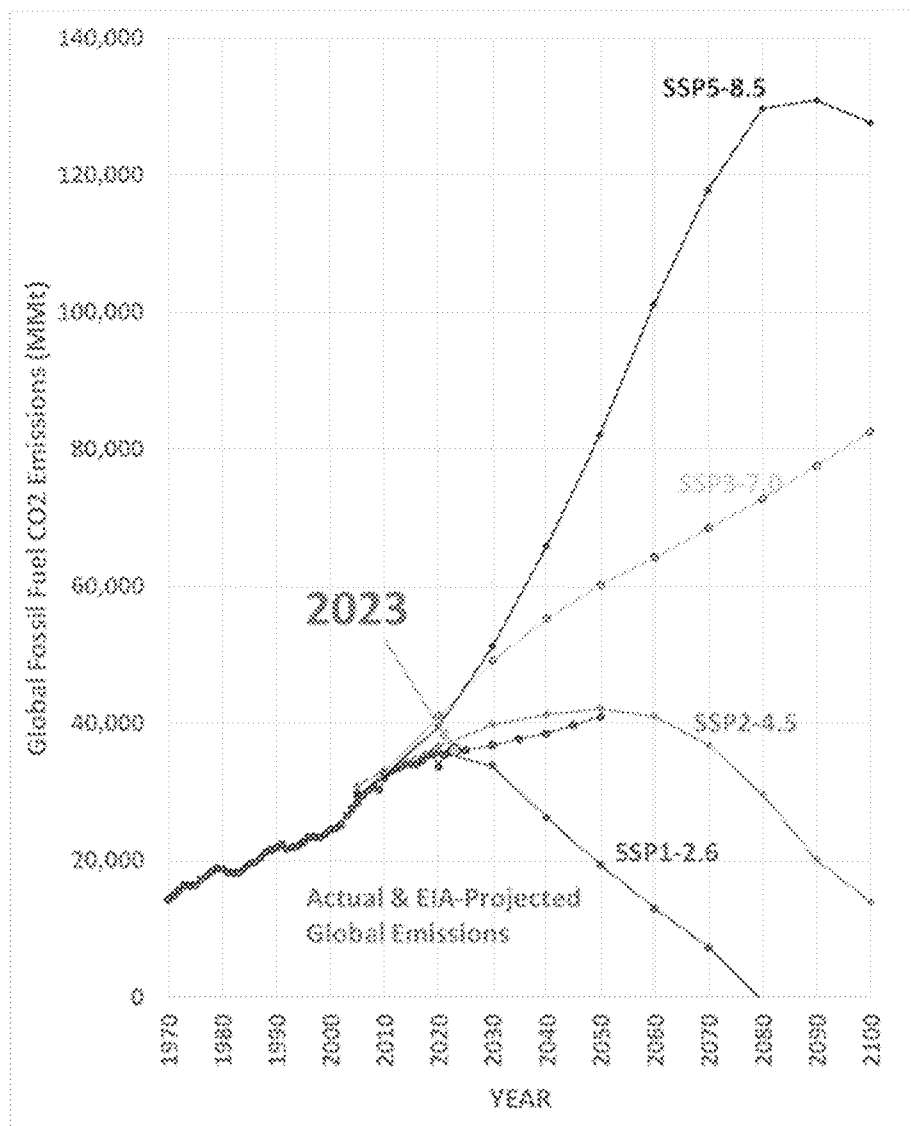


Fig. X2. The Shared Socioeconomic Pathway (SSP) scenarios of future atmospheric CO₂ concentrations used by the IPCC in their CMIP6 climate model projections, compared to actual global emissions (up to 2023) and EIA-projected emissions, 2025-2050 (green).

Also shown in Fig. X2 are the yearly estimates of past global CO₂ emissions (green) along with Energy Information Administration (EIA) future estimates based upon projections in global energy use every five years until 2050.

Importantly, as of 2023 global CO₂ emissions have been tracking *well below* the two highest emissions scenarios used by the IPCC (SSP5-8.5 and SSP3-7.0). This is significant because most of the climate model projections relied upon for energy policy decisions have been from these two emissions scenarios (or similar scenarios), which are now increasingly considered unrealistic (e.g. Ritchie and Dowlatabadi, 2017; Pielke & Ritchie, 2017; Pielke & Ritchie, 2021).

Yet, despite these unrealistically high CO2 concentrations, extreme climate projections are still widely used by the IPCC, environmental groups, and in reports (e.g. the Fifth U.S. National Climate Assessment, NCA5) to warn of the dangers of climate change. In other words, the public and policymakers are being misled by climate model projections showing *what could theoretically happen if CO2 emissions increase drastically, even though recent trends indicate that will not happen*. This is one more reason why current climate model projections, and especially assessments which only highlight unrealistic future emissions scenarios, should not be relied upon for energy policy decisions.

As shown above, there is also increasing evidence for benefits to life on Earth from more CO2 in the atmosphere.

From: Ross McKittrick [ross.mckittrick@gmail.com]
Sent: 4/18/2025 6:28:52 PM
To: Roy W. Spencer [roywspencer@hotmail.com]; John Christy [climateman60@gmail.com]; Steven Koonin [steven.koonin@gmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]
Subject: Section 1.6
Attachments: 1.6 Climate Sensitivity.docx

Roy I took some text from an earlier piece you had written and combined it with my review of empirical ECS to produce a complete draft of Sect 1.6 which is now in your Dropbox folder.
Also attached to this email.

1.6 Measuring Climate Sensitivity to CO₂ Forcing

1.6.1 Model-based methods of computing climate sensitivity to GHGs

Equilibrium Climate Sensitivity (ECS) is defined as the expected amount of warming averaged over the Earth's surface in response to a doubling of CO₂, after all climate systems have had time to adjust. Some systems, like temperatures in the troposphere, adjust very rapidly. Others may take decades or even centuries, such as the deep ocean and the cryosphere. A related metric which is sometimes more helpful on shorter time scales is the Transient Climate Response (TCR) defined as the amount of warming after 70 years in which atmospheric CO₂ goes up by one percent annually.

Although ECS is of intrinsic scientific interest it is also of central importance to evaluating the public danger posed by GHG emissions. As will be discussed in Section 3.6, economic models take the ECS value from climate science and use it to project the costs of CO₂ emissions. The traditional ECS value (3.0 °C) has typically yielded modest global social costs of CO₂ emissions, whereas values closer to 2.0°C have been shown to be compatible with social costs of emissions being zero or even negative this century (Dayaratna et al. 2016, 2020). Obtaining a precise ECS estimate is therefore important for policy guidance.

In large-scale General Circulation Models (aka climate models) ECS is not imposed as a direct parameter, instead it emerges from the behaviour of the underlying components of the model. These, however, are under the control of the modeler, so ultimately a model's ECS can be said to be built into it. Direct warming from CO₂ doubling is only about 1°C (Hall and Manabe 1997); the rest, to the extent more happens, arises due to climate feedbacks which are inherently more difficult to predict and model.

In 1979 the Charney (1979) Report for the US National Academy of Sciences proposed that the most likely value for ECS was 3.0°C plus or minus 1.5°C. Hence the best estimate was a likely tripling of the CO₂ effect through feedbacks. With only minor variations this range was adopted and reaffirmed by the IPCC until the most recent AR6. The range has been obtained primarily by examining the behaviour of climate models, but since key components of models are under the control of modelers this is not dispositive of the actual climate's sensitivity.

There are approximately three dozen computer climate models operated by research groups around the world (Cannon 2024). They are referred to as GCMs which stands for either General Circulation Models or Global Climate Models. GCMs are valuable tools for understanding the climate system from a theoretical perspective. But the models have become so complex, often with 1 million or more lines of computer code (Brown-Steiner 2024), that it would be prohibitively expensive and time consuming for anyone to replicate the models' projections of climate change, let alone test the myriad model approximations embedded in the computer codes; a climate model typically takes hundreds of experts many years to develop (McSweeney and Hausfather 2018). As a result, these models are published in the scientific literature with little to no independent evaluation (Pirtle et al 2010). Climate modeling thus stands as an unusual class of scientific endeavor wherein researchers validating the scientific claims of others — a hallmark of science (National Academy of Science 2019)— becomes impractical, if not impossible.

While the models are often touted as being accurate representations of the “basic physics” governing the climate system, they still have problems with model “drift,” in which the models slowly change temperature over centuries for no apparent reason (Grandey et al. 2023). The tendency to drift is adjusted for by climate modelers by imposing the arbitrary assumption that

Earth's climate system does not produce long-term climate change, unless caused by humans (Sen Gupta et al 2013). By suppressing all slow-moving warming and cooling in this way this biases model-based research away from potential natural causes of climate change. In addition recent research suggests many models do not even conserve energy (Irving 2021) — a violation of the First Law of Thermodynamics. The First Law holds that energy can be neither created nor destroyed; to the extent that climate models fail to conserve energy, it can spontaneously appear (or disappear) for no apparent reason, causing a fictitious temperature change. This is a particularly important consideration since global warming theory is first and foremost based upon tiny changes in the global energy balance assuming the First Law holds.

For all these reasons it should come as no surprise that the various models' responses to a hypothetical doubling of atmospheric CO₂ above pre-industrial levels produces a very wide range of ECS values in current models, from 1.83°C to 5.64°C in the IPCC AR6. This wide range of responses — the largest in over 30 years of the global climate modeling enterprise — demonstrates large remaining uncertainties in climate modeling and thus in the projection of global climate impacts imputed to human activities. It also implies that ECS cannot be determined from climate models alone since the range is too wide to be informative. For that reason scientists have increasingly turned to empirical methods.

1.6.2 Empirical methods of computing climate sensitivity to GHGs

A significant amount of effort since the EF has gone into estimating ECS empirically. There are several challenges to this work.

- First, it requires good data but observations of some key climatic systems, especially the oceans, are available in only very limited amounts.
- Second, identifying the effect of CO₂ requires simultaneously identifying the effect of aerosols. Climate models exhibit warming in response to GHGs but cooling in response to aerosols (Schwartz et al. 2007). Observed 20th century warming can be shown to be consistent either with low ECS and low aerosol cooling or high ECS and high aerosol cooling. Since fossil fuel use adds both GHGs and aerosols to the atmosphere, both effects need to be estimated to isolate the warming effect of CO₂. Over time the IPCC's estimate of the cooling effect of aerosols has declined (Lewis 2022).
- Third, the simple empirical model typically used for the estimation, called an Energy Balance Model, requires estimating a feedback parameter which appears in the denominator of the equation for ECS. A small amount of uncertainty about the number in the denominator of a fraction can lead to very large uncertainties in the magnitude of the fraction itself. Roe and Baker (2007) pointed out that uncertainties in climate feedbacks are "highly amplified" in the resulting ECS.

Since 2012 many studies have appeared in the literature tackling these various uncertainties. A recurring theme is that ECS estimates based on historical data turn out to be smaller than ECS estimates encoded in climate models (Sherwood and Forest 2024). An early estimate (Stern and Kaufmann 2000) was 1.6°C, though this predated development of the Energy Balance Model method. Figure 1.6.1 shows the point or best estimates from 17 subsequent studies all appearing in the peer-reviewed literature after the TSD. The Charney range is shown for contrast. The average ECS estimate in the post-2012 sample is 1.8°C. The highest estimate, from Sherwood et al. 2020, is shown in red: it is the one that was used by the IPCC for the AR6 (Forster et al. 2021). The one

adjacent to it, Lewis (2022), shows the result of, among other things, using the same statistical method (Bayesian inference) but applying more updated aerosol forcing data in the AR6 as well as some other recent updates to the source data. These updates dropped the ECS best estimate to 2.2°C closer to the usual empirical range. The IPCC, following Sherwood et al. (2020) had estimated only a 5 percent probability that ECS was below 2.3°C, whereas Lewis (2022) estimated it was over 50 percent.

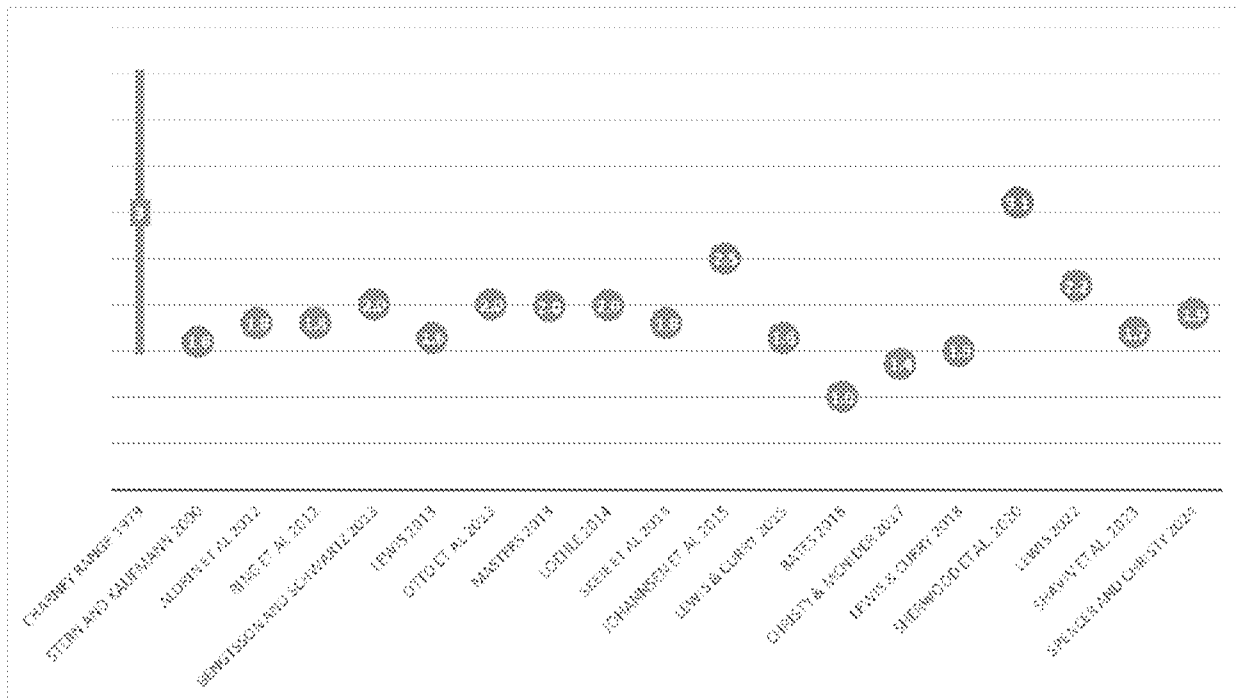


Figure 1.6.1: Empirical best estimates of ECS

A recent hypothesis, which the IPCC AR6 emphasized, is that empirical ECS estimates might understate the future warming response to GHGs due to a so-called “pattern effect” (Forster et al 2021). The tropical Pacific is believed to be highly influential on the overall efficiency with which the Earth’s climate radiates heat to space, but heat in some parts is more efficiently removed than from others. If in a warming climate there is a weakening of the west-to-east temperature gradient in the tropical Pacific the result would be a concentration of warming in a region where heat is less efficiently removed, raising the ECS of the Earth’s climate system. Most climate models simulate that rising GHGs will weaken the east-west temperature gradient, which led the IPCC in the AR6 to conclude that empirical ECS estimates understated what would be the *future* observed ECS value.

However Seager et al. (2019) pointed out that, contrary to models, the east-west temperature gradient has been strengthening rather than weakening over time. They further argued that the mechanism predicting otherwise in climate models was based on a faulty characterization of oceanic dynamics and there is no reason to expect the gradient to weaken. A similar argument was recently made by Lee et al. (2024), who concluded that “the trajectory of the observed trend reflects the response to increasing GHG loading in the atmosphere”, in other words GHG warming should lead to a future strengthening rather than a weakening of the temperature gradient.

Increased efficiency of atmospheric cooling implies, if anything, that the future ECS in a warming climate may be *lower* than at present.

As discussed in Section 1.4.2 a real-world ECS below the model average is supported by studies which show climate models on average estimate too much warming at the surface and in the troposphere compared to observations over the past 50 years. Also it aligns with evidence from consistent fingerprinting (Section 1.5.1) that model responses to GHGs need to be scaled down quite a bit to align with observed trends.

In summary:

- ECS cannot be determined from climate modeling alone since models are too complex and uncertain to narrow the range
- Climate models on average embed process assumptions that yield a projected warming of about 3.0°C from CO₂. Empirical estimates since the TSD however imply the climate is much less sensitive to CO₂ than this.
- A large number of empirical estimates have been published centered at or below 2°C. This aligns with other independent forms of empirical evidence pointing towards low ECS.

From: John Christy <climateman60@gmail.com>
Sent: Monday, April 14, 2025 11:13 AM
To: Ross McKittrick; Steve Koonin; Roy Spencer
Subject: Section 2.1.2 Forecast Skill
Attachments: [2.1.2]Apr14.[JC].docx

Ross

The aspect of improving forecasting skill as a part of an EF reconsideration is new to me. I started looking at some things, but had to come back to the astonishing drop in weather-related deaths of which enhanced forecast skill would be only a bit player. Before I go down a rabbit hole, this is what I wrote. It's not long (and shouldn't be). Is any of this useful?

John C.

CONFIDENTIAL
FOR DISCUSSION PURPOSES ONLY

**Current Scientific Understanding of US Greenhouse Gas Emissions from Motor
Vehicles as an Endangerment to US Citizens**

Section 2.1.2

Forecasting systems for extreme weather [JC]

Weather and climate threats to human life often relate to temperature and precipitation extremes (i.e., hottest, coldest, wettest, driest for given day-lengths) as well as other high-impact events (typically wind-related; hurricanes, tornadoes, wildfires, etc.). In addition, these extremes often determine the survival limits of flora (including agricultural crops) and fauna (including sources of protein for humans). Thus, it is prudent to examine whether changes in these surface extremes have been seen [see 2.2] but here we shall touch on the improvements in resilience with some simple metrics.

The ability to reduce weather-related threats to human survival accelerated in the 20th century as seen in the dramatic drop in deathrates due to such threats (Fig. 2.1.2a). There are many aspects of human progress that explain this reduction such as, agricultural mechanization and irrigation, development of heartier plant and animal species, more robust infrastructure, electrification, transportation that delivers goods and services to meet demand, medical advances, ubiquitous real-time communication devices, etc. One component of this threat-reduction is the improving skill of weather forecasts, allowing the population to be forewarned of potentially dangerous weather and thus seek protection. South Asia, for example, because of extensive satellite coverage, will not again be surprised by land-falling cyclones such as Bhola in 1970 that killed between 300,000 and 500,000 people.

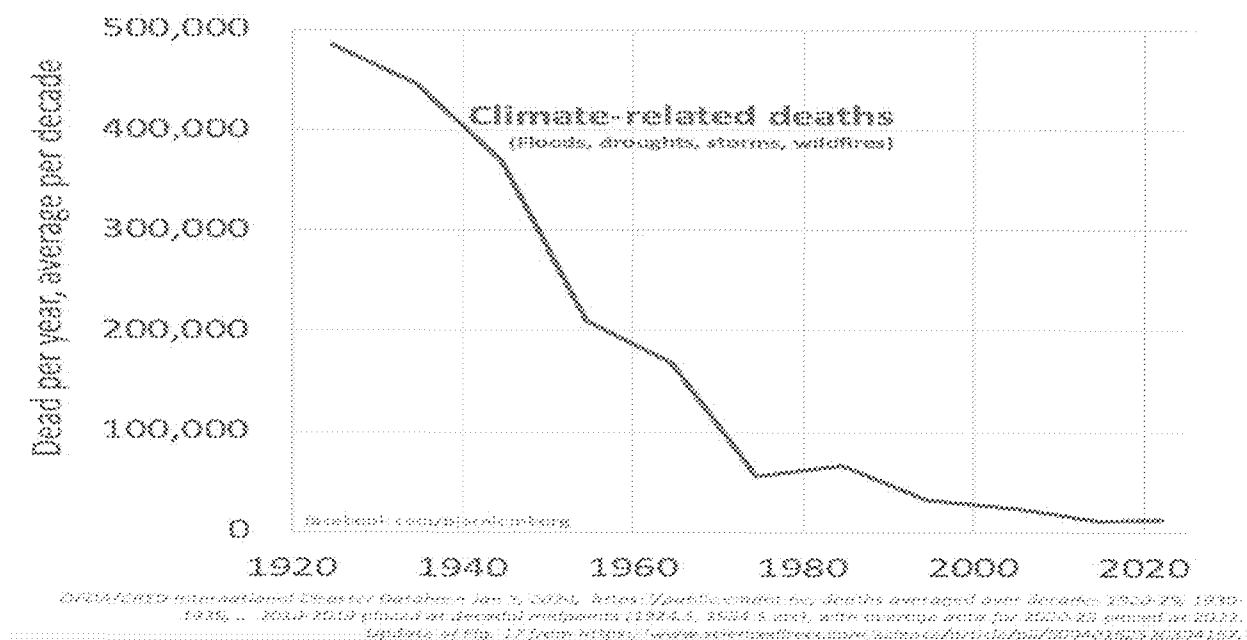


Figure 2.1.2a Climate related deaths as decadal averages (last data point represents 2020-24). OFDA/CRED International Database.

In the US, the forecasting skill of the National Weather Service and other service providers has made tremendous strides in the past 50 years. A recent example was the well-forecasted heatwave, unprecedented in last 150 years, in the Pacific NW in late June 2021 (Mass et al. 2024) for which residents and infrastructure-managers could prepare. In another example, hurricane

forecasts for US landfalls indicate the accuracy of a modern 5-day forecast exceeds the skill of a 2-day forecast from 1970 (Alley et al. 2019).

However, other metrics which represent decisive influences on the reduction of weather-related deaths such as increases in global grain production, access to electricity, and general wealth and longevity make it difficult to quantify the improvements due to increasing forecast skill alone. Lazo et al. 2009 estimated that the overall benefit to US residents of general weather forecasts was \$31.5B at that time. Finally, the likelihood that Artificial Intelligence applications will provide targeted information that is more precise in both space and time and communicated through personal devices suggests even greater protection for US citizens in the coming years. (Lam et al. 2023).

Alley, R.B., K.A. Emanuel and F. Zhang, 2019. Science. 363, no. 6425 342-344.

Lazo, J.K., R.E. Morss, and J.L. Demuth, 2009. Bull. Am. Meteor. Soc., 90, 785.

Lam, R. et al., Learning skillful medium-range global weather forecasting. Science 382, 1416-1421 (2023). DOI: [10.1126/science.adi2336](https://doi.org/10.1126/science.adi2336)

From: John Christy <climateman60@gmail.com>
Sent: Sunday, August 3, 2025 3:40 PM
To: Steve Koonin
Cc: ross.mckittrick@uoguelph.ca; Judy Curry; Roy Spencer; Travis Fisher; Charles Park; Joshua Loucks; Seth Cohen; Audrey Barrios
Subject: Section 5.5 Stratosphere

All

I wanted to do my own check of stratospheric temperature trends. I first did this for a BAMS article in 2016 or so in which models and observations were in OK agreement globally.

Here are the latest lower stratospheric trends for 2000 to 2024, C/decade

Global

-0.05 CMIP-6 median trend
-0.05 Satellites (UAH, RSS, NOAA)
-0.01 Reanalyses (ERA5, JRAQ3)

Tropics

-0.01 CMIP-6
+0.09 Satellites
+0.13 Reanalyses

So, globally, the models DO agree with observations with updated data, and in the tropics they are missing a bit. The point Santer makes is about fingerprinting, but the atmospheric response to extra CO₂ has always been known - cooling stratosphere (especially as one goes higher) and warming tropical troposphere. As I indicated earlier, the magnitude of the pattern is what the models are missing, though they get the fingerprint pattern fairly well.

The current wording pg 39 CWG.

A combination of tropospheric warming and stratospheric cooling is a commonly cited “fingerprint” of anthropogenic climate change. Stratospheric warming since 2000 coincides with continued surface and tropospheric warming, a pattern that is not found in climate model simulations and is not apparently consistent with the anthropogenic fingerprint.

Proposed when we get the reviews sorted out:

A combination of tropospheric warming and stratospheric cooling is a commonly cited “fingerprint” of anthropogenic climate change. Tropical lower stratospheric warming during 2000-2024 (+0.1 °C/decade) coincides with continued surface and tropospheric warming, a pattern that is not found in climate model simulations and is not apparently consistent with the anthropogenic fingerprint. Globally, model-average and observational trends of the lower stratospheric temperature since 2000 (a very small -0.05 °C/decade) are in agreement. In the middle and upper stratosphere, a region with very little atmospheric mass and little connection to the troposphere, temperature responses are evident such as forced by the tiny variations in the 11-year solar cycle and with overall cooling due to changes in CO₂ and Ozone concentrations (Santer et al. 2023).

John C.

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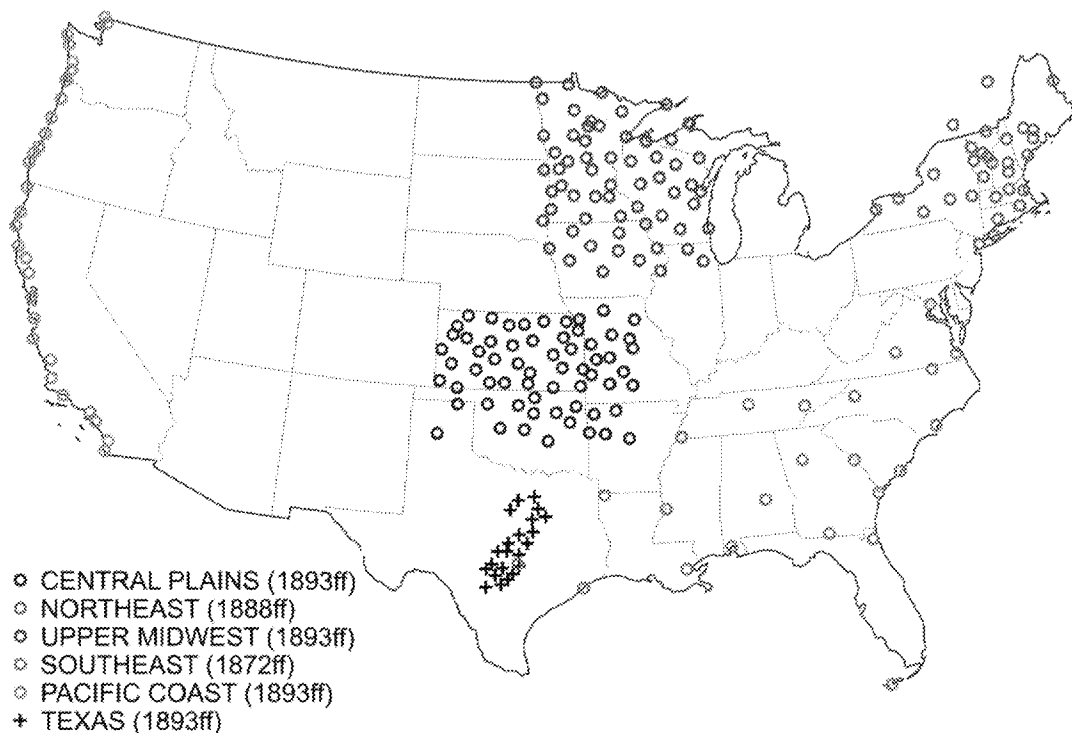
From: John Christy [climateman60@gmail.com]
Sent: 8/4/2025 2:33:08 PM
To: Ross McKittrick [ross.mckittrick@gmail.com]
CC: Judith Curry [curry.judith@gmail.com]; Steve Koonin [steven.koonin@gmail.com]; Roy Spencer [roywspencer@hotmail.com]; Josh Loucks [loucksj14@gmail.com]; Cohen, Seth [seth.cohen@hq.doe.gov]; Travis Fisher [travis.scott.fisher@gmail.com]
Subject: Section 6.4 Precipitation Extremes

All

One of the DoE reviewers criticized the choice of only 3 regions for precipitation extremes in CWG, implying cherry-picking. These three regions were based on all the data I had at the time and addressed three areas that had been pointed out by IPCC and AR5. I've built another three regions (see map) that include the upper midwest, central plains and Texas's "Flash Flood Alley". I also have added a few more in the NE (now 36 stations instead of 27). I have a few stations (12 so far) in the intermountain West, but long-term stations are very difficult to come by in this area.

While it would add a bit to the length of the CWG report and require Ross to execute some more code, we could show that we are responding to this type of criticism (i.e. we are not cherry-picking) even though it takes a tremendous amount of effort to build a single station with uninterrupted data.

John C.



From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Friday, May 23, 2025 10:24 PM
To: Travis Fisher; Josh Loucks; John Christy; Judith Curry; Roy W. Spencer; Steven Koonin
Subject: Some missing references
Attachments: Report Draft May 23[Ref1to3,7to12].docx

Report Draft May 23[Ref1to3,7to12].docx attached and also in Dropbox folder

References done for chapters 1-3 and 7-12. Some missing references, please send if you know what they are:

Chapter 7 MISSING REFERENCE: White 2017

Chapter 8 MISSING REFERENCES:

Bokuchava and Semenov (2021)

Frajka-Williams et al., 2017;

Hegerl et al. (2017);

Hegerl et al. (2019)

Thompson et al. (2010)

Tokinaga et al (2017)

The following were listed in Ch 8 references but not cited in text, please check if some text should be there but isn't.

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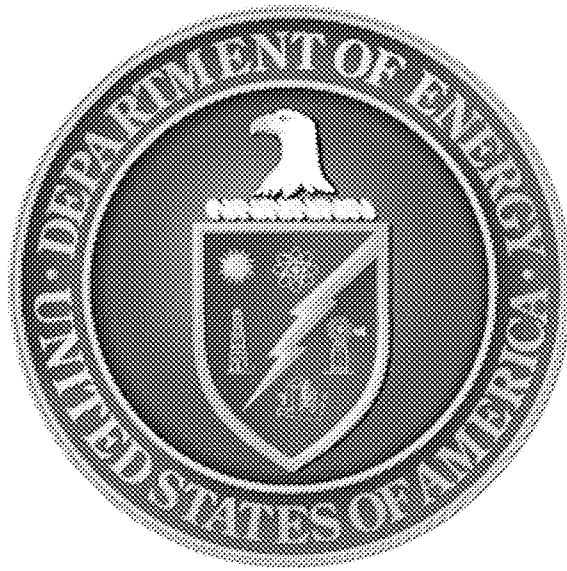
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Impacts of Carbon Dioxide Emissions on the U.S. Climate

CONFIDENTIAL DRAFT FOR DISCUSSION PURPOSES

Ad hoc Climate Working Group
United States Department of Energy
May 28, 2025

CONFIDENTIAL DRAFT FOR DISCUSSION PURPOSES

Impacts of Carbon Dioxide Emissions on the U.S. Climate

Report to US Energy Secretary Christopher Wright

May 28, 2025

Ad hoc Climate Working Group:

John Christy, Ph.D.

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Roy Spencer, Ph.D.

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SECRETARY’S FOREWORD

Energy, Integrity, and the Power of Human Potential

Over my lifetime, I’ve had the privilege of working as an energy entrepreneur across a range of fields—nuclear, geothermal, natural gas, and more—and I now serve as Secretary of Energy under President Donald Trump. But above all, I’m a physical scientist who sees modern energy as nothing short of miraculous. It powers every aspect of modern life, drives every industry, and has made America an energy powerhouse with the ability to fuel global progress.

The rise of human flourishing over the past two centuries is a story worth celebrating. Yet we are told—relentlessly—that the very energy systems that enabled this progress now pose an existential threat. Hydrocarbon-based fuels, the argument goes, must be rapidly abandoned or else we risk planetary ruin.

That view demands scrutiny. That’s why I commissioned this report: to encourage a more thoughtful and science-based conversation about climate change and energy. With my technical background, I’ve reviewed reports from the Intergovernmental Panel on Climate Change, the U.S. government’s assessments, and the academic literature. I’ve also engaged with many climate scientists, including the authors of this report.

What I’ve found is that media coverage often distorts the science. Many people—even well-meaning ones—walk away with a view of climate change that is exaggerated or incomplete. To provide clarity, I asked a diverse team of independent experts to summarize the current state of climate science, with a focus on how it relates to the United States.

I didn’t select these authors because we always agree—far from it. In fact, they may not always agree with each other. But I chose them for their rigor, honesty, and willingness to elevate the debate. I exerted no control over their conclusions. What you’ll read are their words, drawn from the best available data and scientific assessments.

I’ve reviewed the report carefully and challenged its findings. I believe it faithfully represents the state of climate science today. Still, many readers may be surprised by its conclusions—which differ in important ways from the mainstream narrative. That’s a sign of how far the public conversation has drifted from the science itself.

To correct course, we need open, respectful, and informed debate. That’s why I’m inviting public comment on this report. Honest scrutiny and scientific transparency should be at the heart of our policymaking.

Climate change is real, and it deserves attention. But it is not the greatest threat facing humanity. That distinction belongs to global energy poverty. As someone who values data, I know that improving the human condition depends on expanding access to reliable, affordable energy. Climate change is a challenge—not a catastrophe. But misguided policies based on fear rather than facts could truly endanger human well-being.

We stand at the threshold of a new era of energy leadership. If we empower innovation rather than restrain it, America can lead the world in providing cleaner, more abundant energy—lifting billions out of poverty, strengthening our economy, and improving our environment along the way.

EXECUTIVE SUMMARY

This report reviews scientific certainties and uncertainties in how anthropogenic carbon dioxide (CO₂) emissions have affected, or will affect, the Nation's climate, extreme weather events, and selected metrics of societal well-being. Those emissions are increasing the concentration of CO₂ in the atmosphere through a complex and variable carbon cycle, where some portion of the additional CO₂ persists in the atmosphere for centuries.

Elevated concentrations of CO₂ enhance plant growth, globally "greening" the planet and increasing agricultural productivity. They also decrease ocean alkalinity by an amount within the range of natural variability. That is possibly detrimental to coral reefs, although the recent rebound of the Great Barrier Reef suggests otherwise.

Carbon dioxide also acts as a greenhouse gas, exerting a warming influence on climate and weather. The world's several dozen detailed climate models offer little guidance on how the climate responds to that influence, with the average surface warming under a doubling of the CO₂ concentration ranging from 1.8°C to 5.7°C, generally higher than simpler, data driven estimates, which suggest 1.8°C

Detailed climate models generally run "hot" in their description of the climate of the past few decades - too much warming at the surface, in the lower- and mid-troposphere, and too much amplification of warming aloft. They also produce too much recent stratospheric cooling, too much water vapor increase, too much snow loss, and too much warming in the corn belt. The combination of overly sensitive models and extreme scenarios for future emissions has exaggerated projections of future warming.

Most extreme weather events do not show long-term trends. Claims of increased frequency or intensity of hurricanes, tornadoes, floods, and droughts are not supported by historical data. Additionally, forest management practices are an often-overlooked factor in assessing wildfire activity. Global sea level has risen approximately 8 inches since 1900, but there are significant regional variations in tide gauge data driven primarily by local land subsidence; U.S. tide gauge measurements in aggregate do not show any long-term sea level acceleration.

The attribution of particular climate changes or extreme weather events to human CO₂ emissions is challenged by natural climate variability, data limitations, and inherent model deficiencies. Moreover, solar activity's contribution to the warming climate may be underestimated.

Both models and experience suggest that CO₂-induced warming may be less significant economically than commonly believed, and excessively aggressive mitigation policies could prove more detrimental than beneficial. Social Cost of Carbon estimates, which attempt to quantify the economic damage of CO₂ emissions, are highly sensitive to their underlying assumptions and so provide limited independent information.

The report supports a more nuanced and evidence-based approach to climate policy. The risks and benefits of a climate changing under both natural and human influences must be weighed against the costs, efficacy, and collateral impacts of any "climate action", taking into account the nation's need for reliable and affordable energy with minimal local pollution. Assumptions about future emissions should be grounded in reality. Climate models should be re-evaluated to address biases and uncertainties, and the limitations of event attribution studies should be clearly acknowledged. An approach that acknowledges both the potential risks and benefits of CO₂, rather than relying on flawed models and extreme scenarios, is essential for informed and effective decision-making.

INTRODUCTION: OVERVIEW AND PURPOSE OF THIS DOCUMENT

This document originated in late March 2025 when Secretary Wright assembled an independent group to write a report on issues in climate science relevant for energy policymaking, with particular focus on the question of whether carbon dioxide emissions endanger the US public. We agreed to undertake the work on the condition that there would be no editorial oversight by the Secretary, the Department of Energy, or any other government personnel. This condition has been honored throughout the process and the writing team has worked with full independence.

The group began working in early April with a deadline of May 28. The short timeline and the technical nature of the material meant that we could not comprehensively review all topics. While the report is intended to be accessible for non-experts, we have omitted some introductory or explanatory material that can easily be accessed elsewhere. Nor have we attempted to survey entire literatures related to the topics covered. We have focused as much as possible on literature published since 2020 and referenced previous IPCC and NCA assessment reports. We have also used data through 2024 where possible.

The writing team is grateful to Secretary Wright for the opportunity to prepare this report and for his support of independent scientific assessment.

May 2025

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PART I: DIRECT HUMAN INFLUENCE ON ECOSYSTEMS AND THE CLIMATE

1 CARBON DIOXIDE AS A POLLUTANT

Chapter summary

Carbon dioxide (CO₂) differs in many ways from the so-called Criteria Air Pollutants. It does not affect local air quality and has no human toxicological implications at ambient levels. It is an issue of concern because of its potential effects on the global climate, a complex issue that occupies much of this report.

The Clean Air Act of 1970 defined six so-called Criteria Air Contaminants subject to regulation (EPA): particulate matter, ground-level Ozone, Sulfur Dioxide, Nitrogen Dioxide, Lead and Carbon Monoxide (CO). In 2007, the Supreme Court ruled that greenhouse gases (CO₂ among them) were also “pollutants” subject to regulation under Clean Air Act (*Mass. v. EPA*, 2007). While the definition of “pollutant” is ultimately a legal one, there are important scientific distinctions between CO₂ and the Criteria Air Contaminants. The latter are subject to regulatory control because they cause local problems depending on concentrations that include nuisances (odor, visibility), damage to plants, and, at high enough exposure levels, toxicological effects in humans. In contrast, CO₂ is odorless, does not affect visibility and has no toxicological effects at ambient levels. It is a naturally occurring part of the atmosphere and a key component of human and plant respiration. CO₂ is essential for plant photosynthesis and higher levels are beneficial for vegetation. In these aspects, CO₂ is similar to water vapor.

Ambient outdoor air today contains about 430 parts per million (ppm) CO₂, increasing at about 2 ppm per year. The US Occupational Safety and Health Administration issues guidelines for indoor workplaces in which elevated CO₂ might be encountered, such as where dry ice is used. The Permissible Exposure Limit is 5,000 ppm over 8 hours (OSHA, 2024). Allen et al. (2015) reported evidence of diminished performance on some cognitive tasks among workers in office cubicles when exposed to CO₂ levels above 1,000-1,500 ppm. These levels are far larger than any plausible ambient outdoor value through the end of the 22nd century.

The growing amount of CO₂ in the atmosphere directly influences the earth system by promoting plant growth (global greening), thereby enhancing agricultural yields, and by neutralizing ocean alkalinity. But the primary concern about CO₂ is its role as a greenhouse gas (GHG) that alters the earth’s energy balance. How the climate will respond to that influence is a complex question that will occupy much of this report.

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2 DIRECT IMPACTS OF CO₂ ON THE ENVIRONMENT

Chapter summary

CO₂ enhances photosynthesis and improves plant water use efficiency, thereby promoting plant growth. Global greening due to increased CO₂ levels in the atmosphere is well-established on all continents.

CO₂ absorption in sea water reduces the alkalinity of the oceans. The recent decline in alkalinity is within the range of natural variability on millennial time scales. Most ocean life evolved when the oceans were mildly acidic. Declining alkalinity might adversely affect corals, although the Australian Great Barrier Reef has shown considerable growth in recent years.

2.1 CO₂ and global greening

The growing CO₂ concentration in the atmosphere has the important positive effect of promoting plant growth by enhancing photosynthesis and improving water use efficiency. That is evident in the “global greening” phenomenon discussed below, as well as in the improving agricultural yields discussed in Chapter 10.

2.1.1 Measurement of global greening

“Greening” refers to an increase in the fraction of the Earth’s surface covered by plants. It can be quantified by the “Leaf Area Index” (LAI) measured by satellite. Many studies over the past decade have confirmed a global greening pattern (increase in LAI) attributable to rising CO₂ levels. Zhu *et al.* (2016) was one of the first studies to report that global greening was detectable using satellite sensors. From 1982 to 2011 they detected greening over 25-50% of the Earth versus “browning” over only 4% and attributed 70% of the greening to rising CO₂ levels (see Figure 2.1).

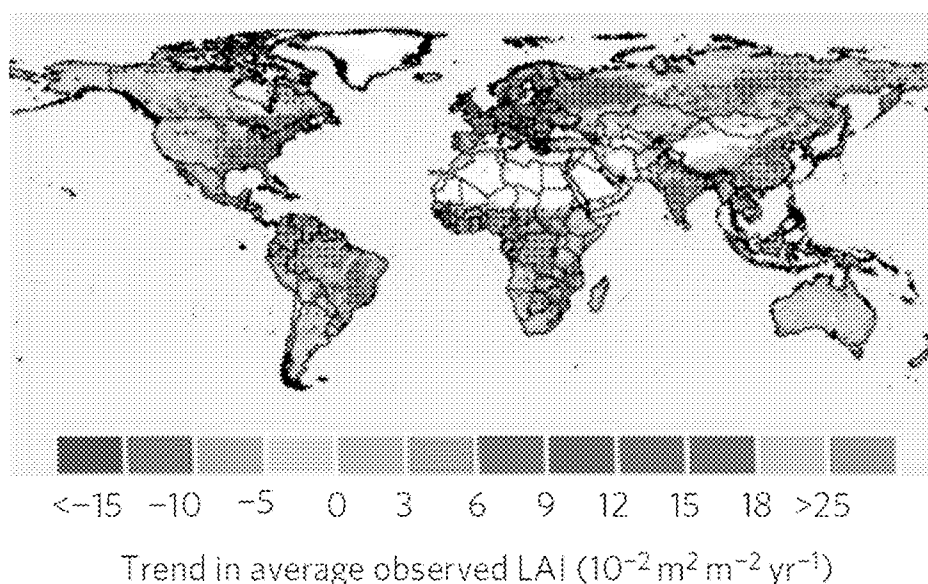


Figure 2.1: Trends in average Leaf Area Index (LAI). Source: Zhu et al. 2016 Figure 3.

Zheng (2017) confirmed the pattern, noting that greening over thirty years had added 8% to global leaf area and that greening was mitigating warming. Greening has been observed globally but Chen et al. (2019) noted that China and India were exploiting it through land management changes. Thus, while China accounts for only 6.6% of global vegetated area it accounts for 25% of global net increase in LAI. Piao et al. (2020) noted that greening was even observable in the Arctic.

While plant models predict increased in photosynthesis in response to rising CO₂, Haverd et al. (2020) reported a CO₂ fertilization rate nearly double what models had predicted. That is, CO₂ fertilization had driven an increase in observed global photosynthesis by 30% since 1900, versus 17% predicted by plant models. This indicates that global models of the socioeconomic impacts of rising CO₂ have likely understated the benefits to crops and agriculture. The connection between CO₂ fertilization and climate policy will be discussed in Chapter 10.

Finally, Chen et al. (2024) surveyed claims that greening had slowed since 2000 due to drought stress. They found instead that faulty satellite sensors were the cause and that the corrected data showed accelerated greening over 55% of the globe while browning was accelerating over only 7%. In other words, the greening trend continued with no evidence of slowdown, and CO₂ fertilization remained the dominant driver

2.1.2 Photosynthesis and CO₂ levels

Plants build biomass through *photosynthesis*, a process that converts carbon dioxide, water, and light into sugar. The plant enzyme responsible for photosynthesis is called Ribulose-1,5-bisphosphate-carboxylase/oxygenase or “Rubisco”. Photosynthesis is initiated when CO₂ is available at the surface of the RuBisCo enzyme where it is converted to a molecule with 3 carbon atoms and thereafter incorporated into plant mass. This is referred to as the “C3” process.

Rubisco is estimated to have evolved about 3 billion years ago. Over geological time the Earth’s atmospheric CO₂ levels were usually many times higher than they are today, as shown in Figure 2.2.

About 400 million years ago CO₂ levels were an estimated 2,000-4,000 ppm and were at or above 1,000 ppm for much of the interval from 200 to 50 million years ago (Berner 2006, Judd et al. 2024). Over the past 35 million years the level of atmospheric CO₂ has been steadily declining. During glaciations levels have fallen as low as 170 ppm (Gerhart and Ward 2010).

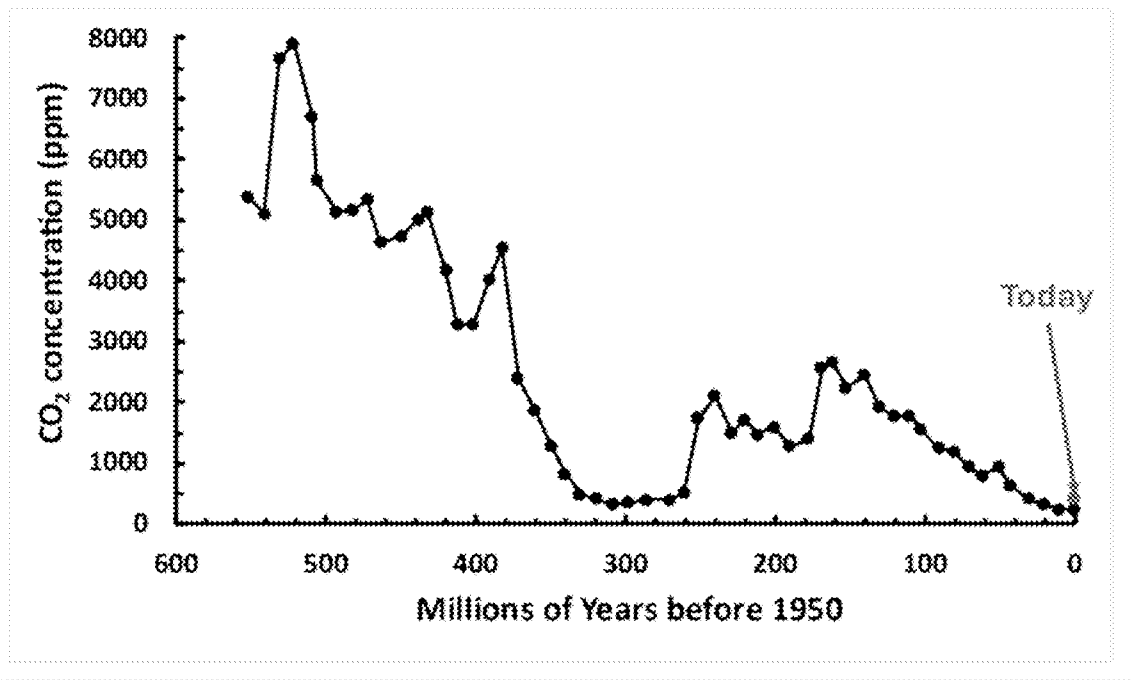


Figure 2.2. Ambient CO₂ levels over the past 550 million years. Today's concentration of 430 ppm is also shown. Source: (Berner 2006)

In response to low-CO₂ conditions some plants evolved another photosynthetic pathway called C₄, in which CO₂ is concentrated in the vicinity of Rubisco allowing for the C₃ process to function more efficiently. For agricultural purposes the plant categories are:

- C₃: rice, wheat, soybeans and most other crops
- C₄: maize (corn), sugar cane, millet, sorghum

Had atmospheric CO₂ levels continued declining, plant growth rates would have declined and eventually ceased. Below 180 ppm many C₃ species experience growth rate reductions on the order of 40-60% compared to their growth rates at 350 ppm (Gerhart and Ward 2010). C₃ plants have been observed under experimental conditions to stop growing altogether at levels between 60—140 ppm CO₂. Some C₄ plants are still able to grow at levels even as low as 10 ppm, albeit very slowly (Gerhart and Ward 2010).

Currently, CO₂ levels are about 420 ppm, up from 280 ppm in the early 1800s. The positive response of plants to extra CO₂ is illustrated in Figure 2.3 which is reproduced from Gerhart and Ward (2010). It shows the growth effect of CO₂ on Velvetleaf (*Abutilon theophrasti*) seedlings over 14 days under controlled conditions where only the CO₂ exposure is varied. The gains exhibited from increasing CO₂ from 150 ppm to 350 ppm continue under a further doubling to 700 ppm.

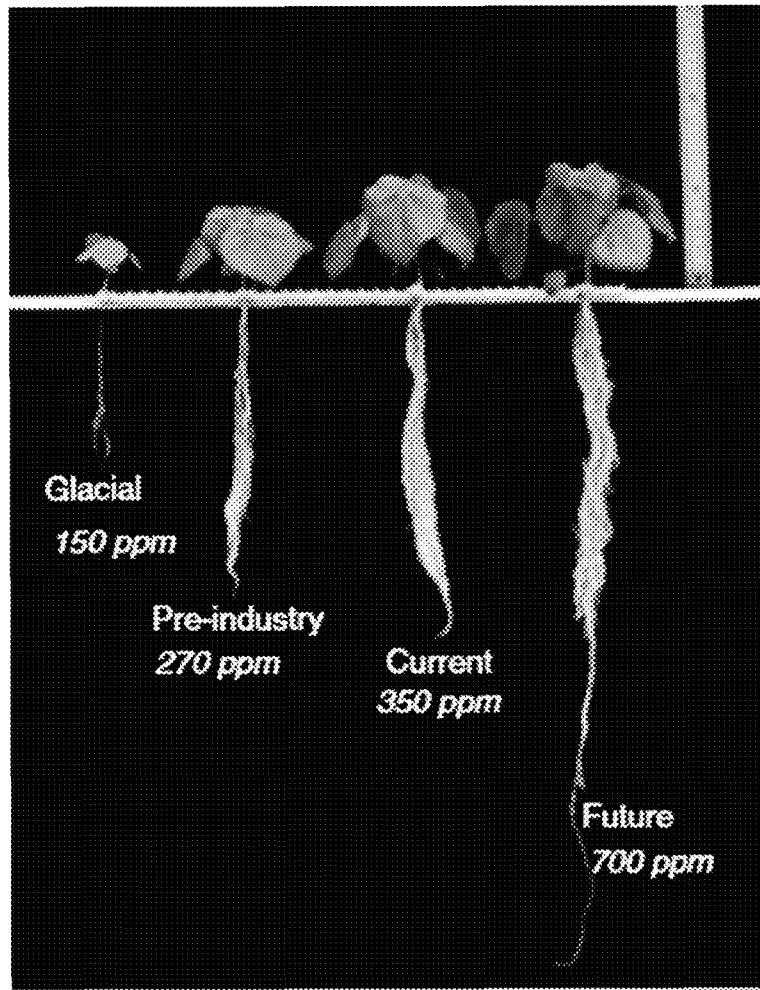


Figure 2.3: growth of *Abutilon theophrasti* after 14 days under identical conditions but for the indicated variations in CO₂ levels. Source: Gerhart and Ward (2010). Note “Current” refers to 2010 in image.

Over the past 60+ years there have been thousands of studies on the response of plants to rising CO₂ levels. The overwhelming theme is that plants, especially C3 plants, benefit from extra CO₂. There are two mechanisms by which CO₂ confers a growth benefit:

- Enhanced photosynthesis via the metabolic pathways described above.
- Increased water use efficiency. This arises because plants draw in CO₂ by opening the stomata (pores) on the leaf surface. When CO₂ is scarce the stomata must be kept wide open for long periods, which allows water to evaporate away. Under enriched CO₂ conditions the stomata are closed for longer periods helping the plant retain water longer, thereby increasing water use efficiency.

Specific effects of climate change on US agriculture will be reviewed in Chapter 10.

2.1.3 *Rising CO₂ and crop water use efficiency*

Deryng et al. (2016) surveyed evidence on crop water productivity (CWP), the yield per unit of water used, drawing attention to the potential for CO₂ both to enhance photosynthesis and reduce leaf-level transpiration (water loss during leaf respiration). They surveyed all available FACE data (Free Air CO₂ Enrichment—see Chapter 10) on crop yield changes for Maize (corn), Wheat, Rice and Soybean, and combined it with crop model data simulating yield responses as of 2080 under the extreme RCP8.5 scenario in four growing regions (Tropics, Arid, Temperate and Cold) each of which were split into rainfed and irrigated sub-regions. In every region they reported that models without CO₂ fertilization predicted CWP losses but CO₂ fertilization more than offset them so that all regions showed a net CWP gain. Deryng et al (2016) also reported that negative impacts of warming on wheat and soybean yields were fully offset by CWP gains and mitigated by up to 90% for rice and 60% for maize.

Similarly, Cheng et al. (2017) noted that increased global plant growth from 1982 to 2011 due to rising CO₂ uptake was accompanied by such large gains in CWP that despite the extra biomass global water use by plants had not increased.

Deryng et al. (2016) assumed that climate change would “exacerbate water scarcity”. It is noteworthy that while models predict drylands will expand under climate warming, current data show the opposite: greening is happening even in arid areas. Zhang et al. (2024) report that due to increased CO₂ levels “increasing aridity in drylands won’t lead to a general loss of vegetation productivity”; increased desertification will happen in at most 4% of currently arid areas.

2.1.4 *CO₂ fertilization benefits in IPCC Reports*

The IPCC has only minimally discussed global greening and CO₂ fertilization of agricultural crops. The topic is briefly acknowledged in a few places in the body of the IPCC 6th and earlier Assessment Reports but is omitted in all Summary documents. Section 2.3.4.3.3 of the AR6 Working Group I report entitled “global greening and browning” points out that the IPCC Special Report on Climate Change and Land had concluded with *high confidence* that greening had increased globally over the past 2-3 decades. It then discusses that there are variations in the greening trend among data sets, concluding that while they have *high confidence* greening has occurred, they have *low confidence* in the magnitude of the trend. There are also brief mentions of CO₂ fertilization effects and improvements in water use efficiency in a few other chapters in the AR6 Working Groups I and II Reports.

Overall, however, the Policymaker Summaries, Technical Summaries and Synthesis Reports fail to discuss the topic.

2.2 **Ocean Alkalinity**

2.2.1 *Changing pH*

A neutral aqueous solution has a pH of 7.0, while one with pH greater than 7.0 is basic and with pH less than 7.0 is acidic. The modern-day global average pH of sea water is estimated to be 8.04 (Copernicus Marine Service 2025), down from an estimated value of 8.2 in pre-Industrial times (Gattuso and Hansson, 2011). As CO₂ concentrations in the atmosphere increase, more is absorbed by the oceans, which decreases alkalinity. Depending upon the buffering capacity of the oceans, the oceans are expected to become somewhat less alkaline over time, consistent with the observed decrease in pH.

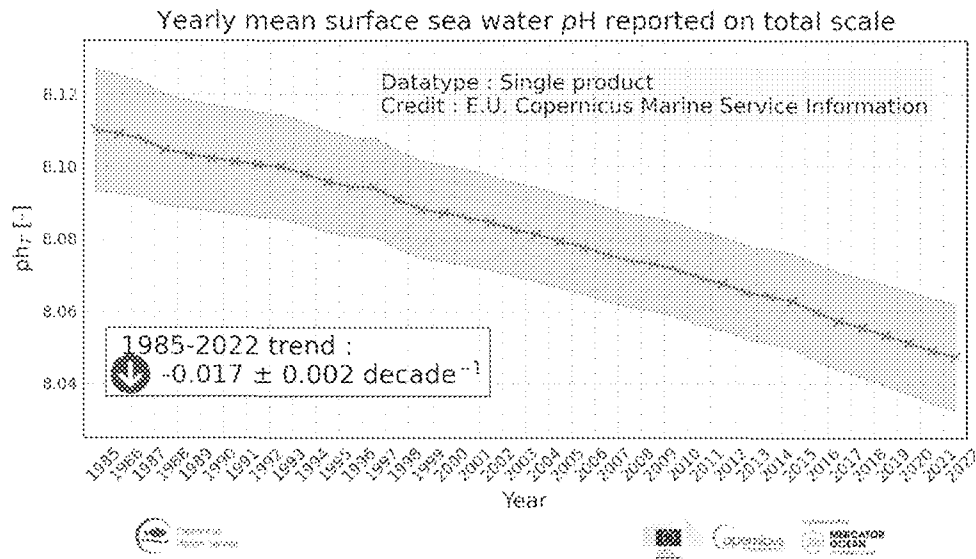


Figure 2.4: Ocean pH 1985 – 2022. Source: Copernicus Marine Service 2025

While this process is often called “ocean acidification”, it is a misnomer because the oceans are not expected to become acidic; “ocean neutralization” would be more accurate. Even if the water were to turn acidic, it is believed that life in the oceans evolved when the oceans were mildly acidic with pH 6.5 - to 7.0 (Krissansen-Totton et al., 2018). On the time scale of thousands of years, boron isotope proxy measurements of pH show that ocean pH was around 7.4 or 7.5 during the last glaciation (up to about 20,000 years ago) increasing to present-day values as the world warmed during deglaciation (Rae et al., 2018). Thus, there appears to be considerable resilience of ocean biota to natural long-term changes in ocean pH since marine organisms are exposed to wide ranges in pH anyway.

2.2.2 Coral reef changes

There are concerns that a decreasing pH of sea water will reduce the calcification rate of coral reefs. But coral reefs already endure large swings in pH, partly due to daily photosynthetic activity in the reef; measured pH values range from 9.4 during the day to 7.5 at night (Revelle and Fairbridge, 1957). De’ath et al. (2009) reported that a portion of Australia’s Great Barrier Reef (GBR, the world’s largest coral reef ecosystem) had experienced a 14% decline in calcification since 1990. This was tentatively attributed to increasing water temperature and decreasing pH. But Ridd et al. (2013) showed that report to have resulted from a biased data analysis which, when corrected, showed no change in calcification rates. Nevertheless, the alarm produced by the original paper has persisted as evidenced by the large number of published citations (541) received by the original study compared to only 11 citations for the correction (as of 30 April 2025).

The most recent annual summary of GBR conditions from the Australian Institute of Marine Science indicates a strong rebound has occurred in coral production (AIMS, 2023). Figure 2.5 shows the results of the AIMS surveys of hard coral cover, expressed as a percentage of the reef area. Much of the decline in the GBR before 2011 turned out to be due to intense tropical cyclone activity (Beeden et al., 2015) as well as a string of marine heatwaves, agricultural runoff and invasive species (Woods Hole, 2023). Given the reported declines in GBR calcification between 1990 and 2009 and the continued increase in atmospheric CO₂ levels the rebound has come as a surprise to some observers.

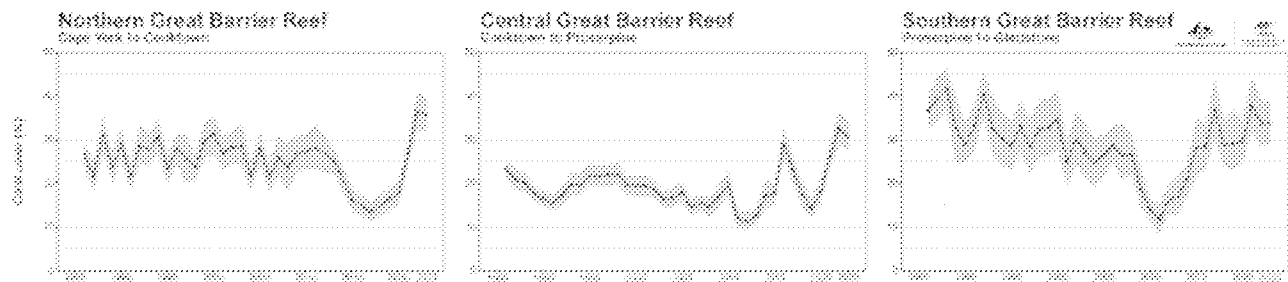


Figure 2.5 Hard coral cover of three regions of the Great Barrier Reef 1985 to 2023. Source: AIMS 2023.

It is being increasingly recognized that publication bias (alarming ocean acidification results preferred by high-impact research publications) exaggerates the impacts of declining ocean pH. An ICES Journal of Marine Science Special Issue addressed this problem with an article entitled, *Towards a Broader Perspective on Ocean Acidification Research*. In the Introduction to that Special Issue, H. I. Browman stated, “As is true across all of science, studies that report no effect of ocean acidification are typically more difficult to publish.” (Browman, 2016).

Similarly, a meta-analysis (Clements et al., 2021) of the negative effects of ocean acidification on reef fish behavior found what they called a “decline effect”: initially dramatic conclusions published in prominent journals showing apparently large reported effects of acidification tended to be followed up by subsequent studies on larger sample sizes yielding much smaller and typically non-existent effects. They call for their colleagues to improve research practices to prevent the “decline effect” from persisting:

[The] vast majority of studies with large effect sizes in this field tend to be characterized by low sample sizes, yet are published in high-impact journals and have a disproportionate influence on the field in terms of citations. We contend that ocean acidification has a negligible direct impact on fish behavior, and we advocate for improved approaches to minimize the potential for a decline effect in future avenues of research (Clements et al., 2021).

In summary, ocean life is complex and much of it evolved when the oceans were acidic relative to the present. Much of the public discussion of the effects of ocean “acidification” on marine biota has been one-sided and exaggerated. There is a known tendency for studies reporting dramatic effects on things like coral cover and fish behavior to get published in high-impact journals and receive widespread press coverage, then subsequent research rebutting those findings receives little attention.

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3 HUMAN INFLUENCES ON THE CLIMATE

Chapter Summary

The global climate is naturally variable on all time scales. Anthropogenic CO₂ emissions add to that variability by changing the total radiative balance in the atmosphere.

The IPCC has downplayed the role of the sun in climate change but there are plausible solar irradiance reconstructions that imply it contributed to recent warming.

Climate projections are based on IPCC emission scenarios that have tended to exceed observed trends. The vast majority of academic climate “impacts” studies in recent years are based upon the extreme 8.5 scenario that is now considered implausible; its use as a business-as-usual scenario has been misleading.

Carbon cycle models connect annual emissions to growth in the atmospheric CO₂ stock. Models disagree over the rate of land and ocean CO₂ uptake but all agree that it has been increasing since 1959.

3.1 Components of radiative forcing and their history

3.1.1 Historical radiative forcing

A changing climate has been the norm throughout the Earth’s 4.6-billion-year history. The Earth’s temperature and weather patterns change naturally over timescales ranging from decades to millions of years. Natural variations in the surface climate originate in two ways. Internal climate fluctuations associated with circulations in the atmosphere and ocean produce exchanges of energy, water, and carbon between the atmosphere, oceans, land, and ice. External influences on the climate system include variations in the energy received from the sun and the effects of volcanic eruptions. Human activities influence climate through changing land use and land cover. Humans are also changing the composition of the atmosphere by emissions of CO₂ and other greenhouse gases and by altering the concentration of aerosol particles in the atmosphere.

The earth is warmed by the sunlight it absorbs and is cooled by the radiative heat it emits to space. Averaged over the Earth’s surface, each of these processes involve power flows of about 240 Watts per square meter (W/m²). When they are in balance, there are no net external causes of warming or cooling. Both human and natural influences on the climate alter this balance and so cause the climate to change.

Influences on the Earth’s energy balance at the top of the atmosphere are quantified by “radiative forcing”, the extent to which they disturb the warming/cooling balance; a positive forcing warms while a negative forcing cools. The IPCC’s estimated history of major components of radiative forcing since 1750 is shown in the following two figures from its AR6.

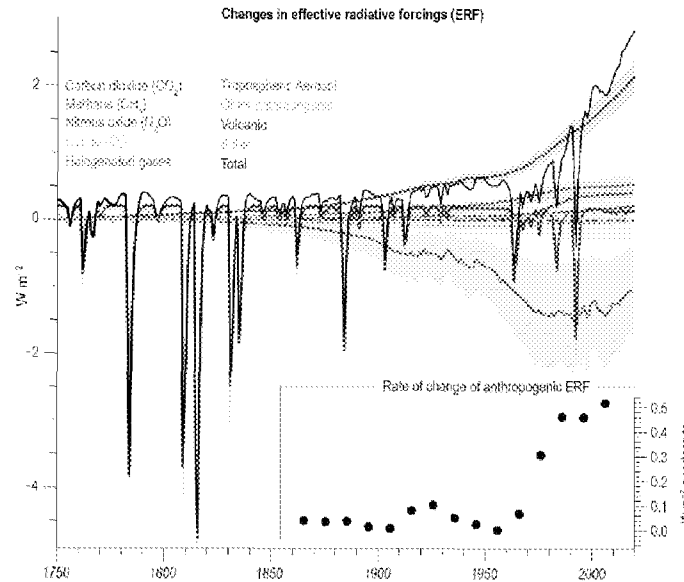


Figure 3.1.1: IPCC estimates of radiative forcing components over time. Source: <https://www.ipcc.ch/report/ar6/wg1/figures/chapter-2/figure-2-10/>

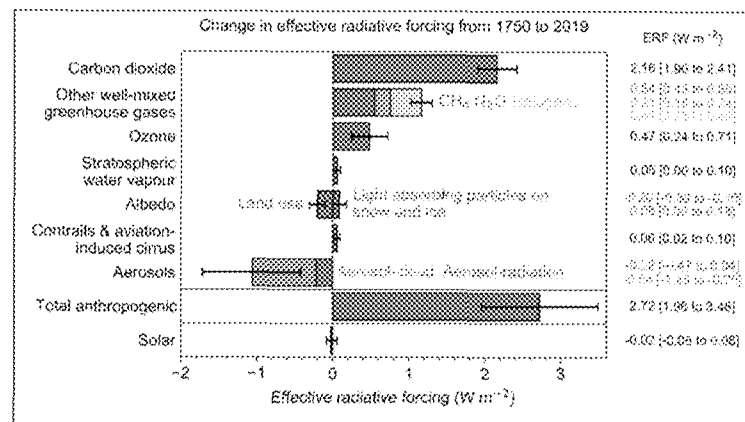


Figure 3.1.2 IPCC estimates of radiative forcing component changes from 1750 to 2019. Source: <https://www.ipcc.ch/report/ar6/wg1/figures/chapter-7/figure-7-6/>

These graphs show that the total radiative forcing is comprised of both natural and anthropogenic components. Carbon dioxide is the largest human influence on the climate and the one most relevant to the influence of energy systems. It exerts a warming influence by decreasing the cooling power of the atmosphere. Emissions of CO₂ are accumulating in the atmosphere, as described in the following section, so that the warming influence is increasing. Other greenhouse gases (methane, nitrous oxide, halogens, and ozone) act similarly, currently adding another 75% to CO₂'s warming. Aerosols exert a cooling effect, although with large uncertainties in the way they catalyze the formation of reflective clouds. As a result, understanding the causes of recent warming requires not just identifying the warming effects of CO₂, but also the more uncertain cooling effects of aerosols.

The IPCC views the change in the radiative forcing by the sun to be negligible, based on their preference for reconstructions that imply minimal solar change since preindustrial times. Connolly *et al.* (2021) reviewed sixteen different Total Solar Irradiance (TSI) reconstructions in the literature covering the 1600-2000 interval; they vary from almost no change in TSI to a relatively large upward trend. Those authors note that the variation in TSI reconstructions combined with variations in surface temperature reconstructions allows for inferences consistent with either no or most 20th Century warming being attributable to the sun.

A particularly thorny issue is the gap in TSI data between 1989 and 1991 due to a delay in the launch of a monitor following the Space Shuttle Challenger disaster on January 28 1986. That prevented a replacement satellite from being launched in time to overlap with, and its readings to be intercalibrated with, the prior system (Zacharias 2014, Scafetta et al. 2019). This is called the ACRIM (Active Cavity Radiometer Irradiance Monitor) gap problem. The question of whether there is an upward trend in TSI over 1978 to 2018 comes down to how the ACRIM data gap is filled. Connolly et al. (2021) found that the IPCC’s consensus statements on solar forcing were prematurely formulated through the suppression of dissenting scientific opinions.

The other natural radiative forcing component is largely volcanic aerosols, which exert an episodic cooling influence. Box 4.1 in the IPCC AR6 Report addresses the climate impact of volcanic eruptions, noting three explosive volcanic eruptions that occurred in the first half of the 19th century. This included the 1815 Tambora eruption that resulted in the ‘year without summer’, with multiple harvest failures across the Northern Hemisphere. There is uncertainty about the sign of the relatively small forcing due to the submarine volcano Hunga Tonga which erupted in 2022 (Jenkins et al. 2023, Schoeberl et al. 2024).

The anthropogenic forcing component was negligible before about 1900 and has increased steadily since, rising to almost 3 W/m² today. However, this is still only about 1 percent of the unperturbed radiation flows, making it a challenge to isolate the effects of anthropogenic forcing; state-of-the-art satellite estimates of global radiative energy flows are only accurate to a few W/m². Natural sources of global energy imbalance other than volcanoes and total solar irradiance (TSI) are not included in these graphs because they remain largely unknown.

3.1.2 Change in atmospheric CO₂ since 1958

Carbon dioxide’s warming influence depends upon how much “extra” CO₂ accumulates in the atmosphere- *i.e.*, its concentration above the preindustrial value of 280 ppm. The CO₂ level as recorded at the Mauna Loa observatory in Hawaii is generally used as the representative global average concentration. The data are available online at <https://gml.noaa.gov/ccgg/trends/index.html>. The concentration was about 316 ppm at the start of the record in 1959 and is now about 430 ppm, a 36 percent increase. At the end of the last glaciation CO₂ levels had fallen to about 180 ppm. As discussed in Chapter 2 C3 plants begin dying at CO₂ levels below about 140 ppm and C4 plants at CO₂ levels below 100 ppm, so if CO₂ levels had continued falling plant life might have been in peril.

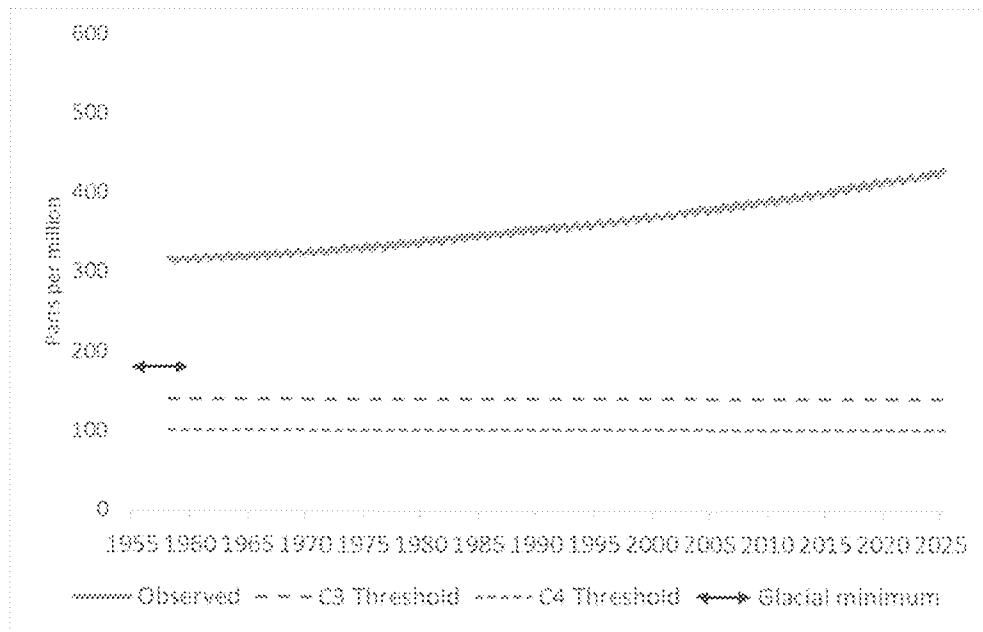


Fig. 3.1.3. CO₂: Yearly average atmospheric CO₂ concentrations (1959-2025) in ppm measured at Mauna Loa (blue). C3 Threshold: Level below which C3 plants begin dying (140 ppm, see Chapter 2). C4 Threshold: Level below which C4 plants begin dying (100 ppm, see Chapter 2). Glacial minimum: Minimum level during recent glaciations (purple arrow). CO₂ data source: <https://gml.noaa.gov/ccgg/trends/index.html>

The annual increase in concentration is only about half of the CO₂ emitted because land and ocean processes currently absorb “excess” CO₂ at a rate approximately 50% of the human emissions. Future concentrations, and hence future human influences on the climate, therefore depend upon two components: (1) future rates of global human CO₂ emissions, and (2) how fast the land and ocean remove extra CO₂ from the atmosphere. We discuss each of these in turn.

3.2 Urbanization influence on temperature trends

Historical temperature data over land has been collected mainly where people live. This raises the problem of how to filter out non-climatic warming signals due to Urban Heat Islands (UHI) and other changes to the land surface. If they are not removed the data may over-attribute observed warming to greenhouse gases. The IPCC acknowledges that raw temperature data are contaminated with UHI effects but claims to have data cleaning procedures that remove them. It is an open question whether those procedures suffice for the purpose.

AR6 downplayed the issue by saying (WGI p. 235) that no recent evidence had emerged to alter the AR5 finding that urbanization causes an upward bias of no more than 10% in the global land surface warming trend. AR5 (WGI p. 189) also cited the 10% upper bound without citing a source. AR4 (WGI p. 244) cited Jones et al. (1990) and Peterson et al. (1999) as the basis of the claim. Peterson et al. had failed to find any difference in trends between rural and urban samples, although their definition of rural included local populations up to 10,000 persons and the relative influence of urbanization begins well below that (Spencer et al., 2025). Jones et al. compared rural/urban warming in three regions: Eastern Australia, Eastern China and Western Soviet Union. Their definition of “rural” included towns of up to 10,000 in the

former Soviet Union and up to 100,000 in China. They found relative warming biases greater than 10% in these areas but conjectured that the urbanization effect averaged over the areas they did not examine would bring the global land bias to under 10% of the observed warming trend.

Prior to the IPCC AR4 several papers appeared in print arguing that the warming effect of UHIs added a relatively large (30-50%) component to observed warming and was not simulated by climate models (de Laat and Maurellis 2006, McKittrick and Michaels 2007). These findings were based on correlations between locations of maximum warming over land with locations of maximum socioeconomic development. AR4 asserted (p. 244) that these correlations were an artefact of natural atmospheric circulations and were in fact statistically insignificant, and on that basis set the findings aside. The claim attracted controversy because it was presented with no supporting evidence. McKittrick (2010) and McKittrick and Nierenberg (2010) showed that taking into account various conjectured alternative explanations for the correlations did not affect their significance. The AR5 (p. 189) conceded that the AR4 had provided “no explicit evidence” for its assessment and further acknowledged, based on these papers, that there was “significant evidence for such contamination of the record” i.e. a warming bias in the land record. However as noted, elsewhere in the report they carried forward the AR4 claim that it was less than 10% of observed warming and they expressed no caution against using the land record for climate measurement on the assumption that it is not contaminated with UHI bias. Recently Soon et al. (2023) estimated an urbanization bias in the Northern Hemisphere land record over 1850-2018 sufficient to increase the trend in the blended record from 0.55°C to 0.89°C per century.

Some studies providing evidence against UHI contamination compared warming rates between rural and urban locations (Jones et al. 1990, Peterson et al. 1999, Wickham et al. 2013). It is not known whether such methods would be capable of detecting UHI bias even when present. The influence of UHI warming is logarithmic, in other words it is strongest at low population growth levels then tapers off as local urbanization expands (Oke 1973, Spencer et al. 2025). Hence finding the same or more warming in rural areas than in nearby urban areas is consistent either with UHI bias being absent or present. McKittrick (2013) provided an empirical demonstration in which the rural/urban trends were not significantly different in a data set shown on other grounds to be contaminated with UHI bias.

Parker (2006) instead examined a sample of urban locations and found no difference in trends between subsets partitioned according to nighttime wind speed, concluding on this basis that urbanization could not be a significant factor. Here again the question is whether such a method would find UHI bias even if present. McKittrick (2013) presented an example in which UHI-contaminated data did not exhibit significant trend differences when stratified according to wind speed.

The challenge in measuring UHI bias is relating local temperature change to a corresponding change in population or urbanization, rather than to a static classification variable such as rural or urban. Spencer et al. (2025) use newly-available historical population archives to undertake such an analyses and found evidence of significant UHI bias in US summertime temperature data.

In summary while there is clearly warming in the land record, there is also evidence that it is biased upward by patterns of urbanization and that these biases are not removed by the data processing algorithms used to produce climate data sets.

3.3 Future emission scenarios and the carbon cycle

3.3.1 Emission scenarios

Because of the great uncertainties about these many factors in the decades to come, Assessing the dangers of future GHG emissions requires assumptions about what those emissions will be. Future emissions, and hence human influences on the climate, will depend upon future demographics, economic

activity, regulation, and energy and agricultural technologies. Various assumptions about each of those lead to projections of greenhouse gas emissions and concentrations, aerosol concentrations, and changes in land use, which ultimately can be combined into assumptions about anthropogenic radiative forcing.

Instead of making precise predictions of future concentrations, the IPCC has created various sets of scenarios meant to span a plausible range of possibilities for population, economy, and technologies. Recent versions of the scenarios are labeled by a number indicating the anthropogenic radiative forcing expected in 2100 under that scenario. Thus, a scenario labeled with a “6” corresponds to 6 W/m² of human-induced radiative forcing (warming) at the end of the century. (Recall current anthropogenic radiative forcing is about 2.7 W/m².)

Although the IPCC does not claim its emission scenarios are forecasts, they are often treated as such. Comparisons of past scenario groups against observations show a tendency for IPCC emission projections to overstate actual subsequent emissions. For the IPCC Third and Fourth Assessment Reports a set of emission projections from the *Special Report on Emission Scenarios* was used; these were referred to as the SREP scenarios. McKittrick *et al.* (2012) showed that, when converted to per capita values, the SREP scenario emissions distribution was skewed upwards and incompatible with observed trends. McKittrick and Wood (2013) further showed that global energy market dynamics constrained global per capita CO₂ emissions to an extent not reflected in IPCC scenarios. The bias of the SRES scenarios was confirmed by the later analysis of Hausfather *et al.* (2019) who showed that observed atmospheric CO₂ concentrations tracked the low end of the SRES range and also of subsequent IPCC scenario ranges.

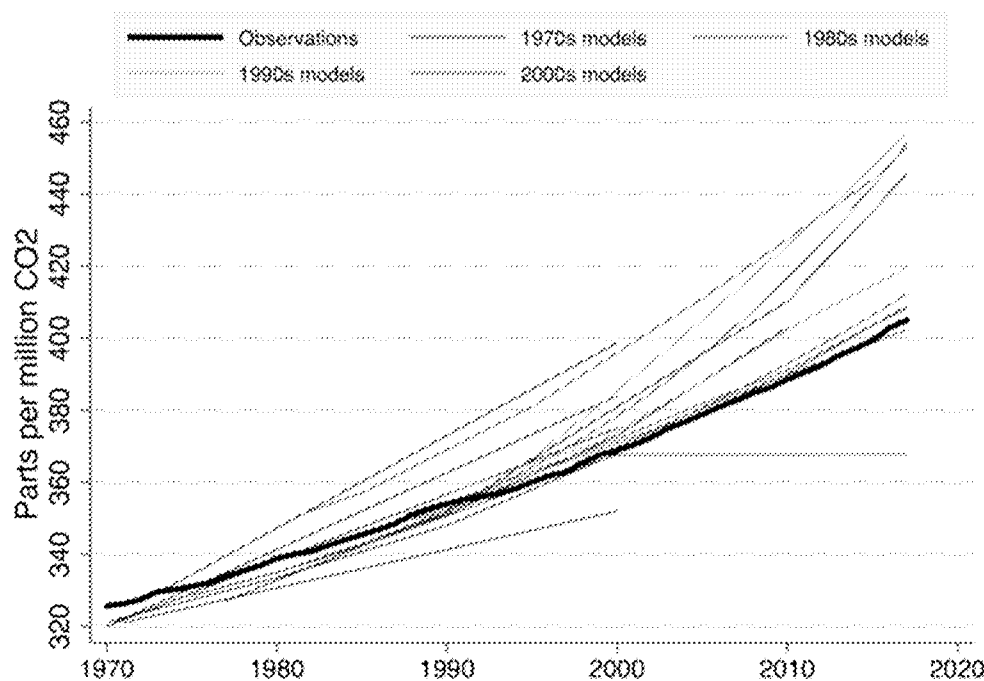


Figure 3.3.1 Comparison of observed atmospheric CO₂ levels (black line) with scenario projections (colored lines, mainly IPCC) since the 1970s. Source: Hausfather *et al.* (2019) Figure S4.

For AR5 the IPCC developed a new set of scenarios called the Representative Concentration Pathways (RCPs). These were identified by a number representing the increase in forcing and were thus called RCP2.6, RCP4.5, RCP6.0 and RCP8.5. RCP2.6 (implying an anthropogenic radiative forcing in 2100 of 2.6 W/m^2) projects a GHG concentration pathway leading to warming well below 2°C . At the other end of the scale RCP8.5 is an extreme outcome implying nearly 5°C warming just in this century.

RCP8.5 came to be referred to as the no-policy baseline, or “business-as-usual” scenario in both the academic literature and popular media. It was therefore used to generate the reference outcome supposedly representing the 21st century world in the absence of increasingly stringent emission reduction policies. But RCP8.5 was intended as a low-probability high emissions scenario and its use as a business-as-usual baseline has been criticized as grossly misleading.¹ Hausfather and Peters (2020) writing in a commentary in *Nature* magazine, pointed out that RCP8.5 was developed as an extreme worst-case, and its misuse as a “business as usual” baseline has resulted in a large number of misleading studies and media reporting.

The implausibility of the RCP8.5 scenario was examined by Burgess *et al.* (2021). They noted that RCP8.5 has already diverged from observed trends in energy use and the near future trends diverge sharply from those of the International Energy Agency (IEA), which provides market-based projections of energy use for the coming decades. The IEA trends, which are based on plausible extrapolations of current economic and demographic trends, run below the entire envelope of RCP projections, implying not only that RCP8.5 is dubious, but that even lower emission scenarios are looking unlikely.

Widespread use of RCP8.5 has created an alarmist bias in the climate impacts literature. The extent of this problem was confirmed in a literature analysis by Pielke Jr. and Ritchie (2020). They found that some 16,800 scientific papers published between 2010 and 2020 used the RCP8.5 scenario, with about 4,500 of the articles linking RCP8.5 to the concept of “business-as-usual”. Their analysis showed how RCP8.5 was misused not only by individual researchers, but also by influential science agencies like the IPCC and the US National Climate Assessment (USNCA), which has directly led to misleading coverage in prominent media outlets.

Pielke and Ritchie (2020) reported new studies using RCP8.5 were published at a rate of about 20 per day, with about two per day specifically linking RCP8.5 and “business as usual.” They conclude that the climate research community has spent a decade “committing scientific resources to science fiction” and that “The scientific literature has become imbalanced in an apocalyptic direction.”

The IPCC developed a new set of scenarios for AR6, the “Shared Socioeconomic Pathway” (SSP) scenarios, which have continued the bias shown in the RCP and SRES scenarios. Figure 3.3.2 shows total global observed CO_2 emissions compiled by the International Energy Agency (IEA) merged with the emission projection from the EIA taking account of energy use projections and current policies. The other lines show the range of IPCC SSP scenarios (SSP1-SSP5). As of 2023, global CO_2 emissions have been tracking well below SSP3 and higher.

¹ This extreme scenario is useful for modelers, since a large forcing generates a large response (warming) making it easier to assess a model’s sensitivity. But that’s very different than claiming it is a plausible future.

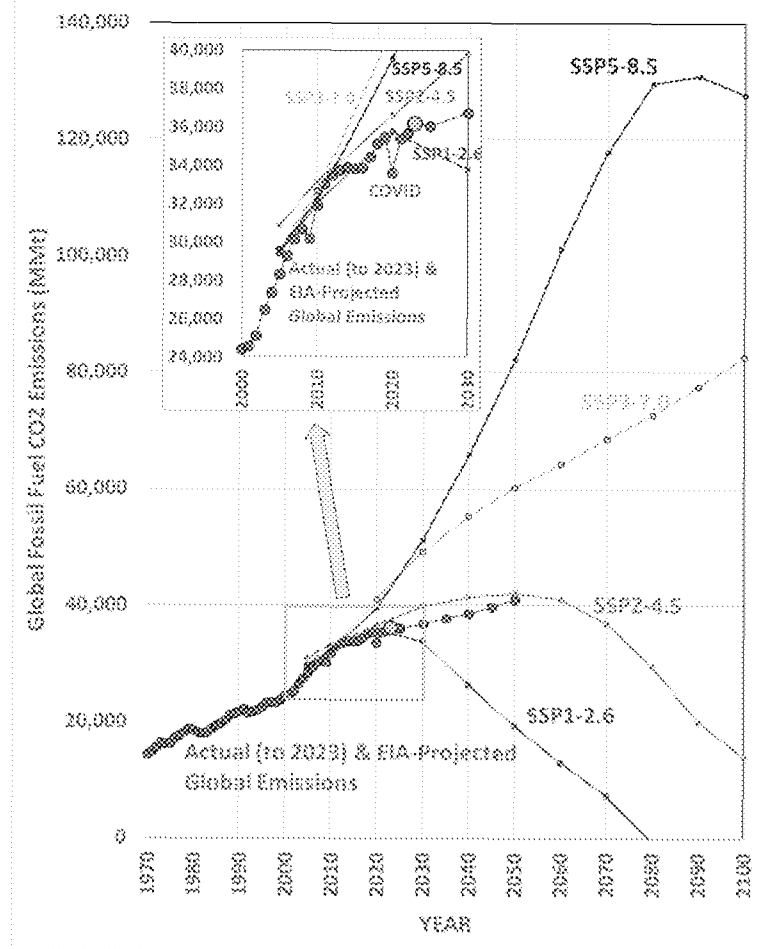


Figure 3.3.2. Observed and projected CO₂ emissions. Source: IPCC (SSP scenarios) and Energy Information Administration (EIA). Green: observed historical emissions and EIA projections. Other lines: SSP1-5. Data source: Friedlingstein et al. (2024).

3.3.2 The carbon cycle relating emissions and concentrations

Carbon dioxide emissions from fossil fuel burning (and to a lesser extent land use [biomass burning] and cement production) have led to steadily increasing CO₂ concentrations in the atmosphere, as shown in Fig. 3.1.3. The relation between emissions and concentration is determined by the global carbon cycle of land and ocean processes that exchange carbon with the atmosphere. Our understanding of these processes was reviewed by Crisp et al. (2021).

There are about 850 Gt of carbon (GtC) in the Earth's atmosphere², almost all of it in the form of CO₂. Each year, biological processes (plant growth and decay) and physical processes (ocean absorption and outgassing) exchange about 200 GtC of that carbon with the Earth's surface (roughly 80 GtC with the land and 120 GtC with the oceans). Before human activities became significant, removals from the atmosphere

² Because CO₂ is chemically transformed through the course of the carbon cycle, it is more convenient to track atoms of carbon rather than molecules of CO₂. One gigatonne of carbon (GtC) is equivalent to about 3.7 Gt of CO₂.

were roughly in balance with additions. But burning fossil fuels (coal, oil, and gas) takes carbon out of the ground and adds it to the annual exchange. That addition (together with a much smaller contribution from cement manufacturing) amounted to 10.3 GtC in 2023, or only about 5 percent of the annual exchange.

The carbon cycle accommodates about 50 percent of humanity’s small annual injection of carbon into the air by naturally sequestering it through plant growth and oceanic uptake, while the remainder accumulates in the atmosphere (Ciais et al., 2013). For that reason, the annual increase in atmospheric CO₂ concentration averages only about half of that naively expected from human emissions.

To project future CO₂ concentrations in the atmosphere, and hence future human influences on the climate, it is important to know how the carbon cycle might change in the future. The historical near-constancy of that 50% fraction means that the more CO₂ humanity has produced, the faster nature removed it from the atmosphere. That 50% fraction changes somewhat from year to year due to natural carbon cycle imbalances from El Nino, La Nina, and varying weather patterns. There was also a substantial additional reduction in atmospheric CO₂ after the 1991 eruption of Mt. Pinatubo, a curious result that has yet to be explained (Angert et al., 2004).

The main processes that remove excess CO₂ from the atmosphere are increased growth of land vegetation (especially at high latitudes), some increase in the sequestering of carbon in soils, and uptake of CO₂ by the ocean due to the increasing partial pressure of atmospheric CO₂ over that of CO₂ dissolved in the ocean. All twenty land carbon cycle models tracked by the Global Carbon Project (Friedlingstein et al., 2024) show land processes have been removing excess CO₂ at an increasing rate since 1959. This is consistent with a “global greening” phenomenon (Chapter 2.1) observed by satellites since monitoring of global greenness began in the 1982.

While land vegetation has been responding positively to more atmospheric CO₂, uptake of extra CO₂ by ocean biological processes remains too uncertain to be measured reliably. Our current understanding of these and many more carbon cycle processes was reviewed by Crisp *et al.* (2021).

CO₂ uptake by land processes

The uptake of extra CO₂ from the atmosphere by land surface processes (as also inferred from global greening) has been modeled with 20 different dynamic global vegetation models, the outputs of which are updated every year by the Global Carbon Project (Friedlingstein, 2024). As seen in Fig. 3.3.3, all of those models agree that vegetation and soils have been sequestering carbon from the atmosphere. But we also see that the long-term trends over 1959 to 2023 (65 years) vary widely between models, by nearly a factor of 7. This demonstrates that there remains considerable uncertainty regarding how fast CO₂ from the atmosphere is being removed by land processes, which in turn translates into uncertainty regarding future atmospheric CO₂ concentrations. Those uncertain future CO₂ concentrations then imply a source of uncertainty in climate model simulations of future climate change.

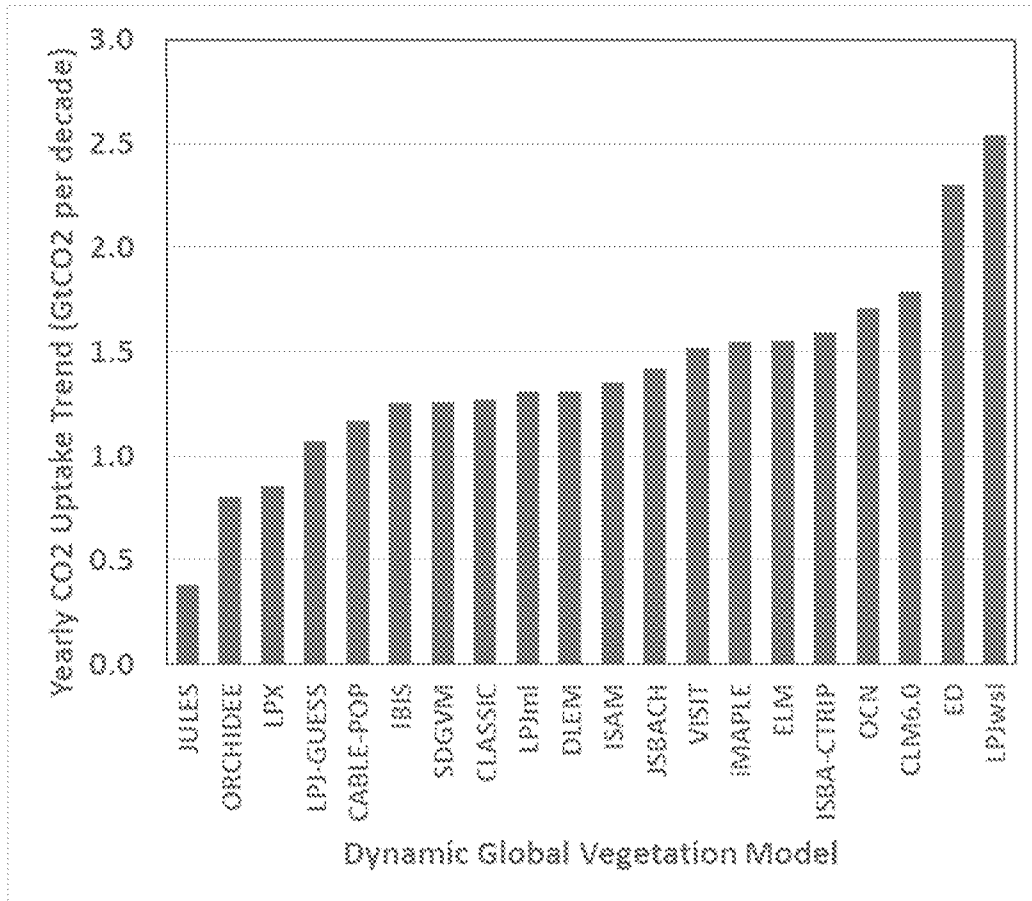


Figure 3.3.3 Decadal trends in the yearly CO₂ uptake by land processes during 1959-2023 simulated by 20 different dynamic global vegetation models periodically reported by the Global Carbon Project (Friedlingstein, 2024).

CO₂ uptake by ocean processes

The uptake of extra CO₂ from the atmosphere by ocean processes has been modeled with 10 different dynamic global vegetation models, the outputs of which are updated every year by the Global Carbon Project (Friedlingstein, 2024). Like the results from the land models, all of the ocean models agree that the global oceans have been sequestering carbon from the atmosphere at an increasing rate during 1959-2023 (Fig. 3.3.4). Unlike the land models, however, the ocean models show much better agreement with each other, with the model producing the fastest increasing CO₂ uptake being only 65% faster than the model with the most slowly increasing CO₂ uptake. Note that the average trend in CO₂ uptake across all land models in Fig. 3.3.3 is 25% larger than the average trend in ocean uptake. This suggests land processes are increasing in their ability to remove CO₂ faster than ocean processes are increasing their CO₂ sequestration.

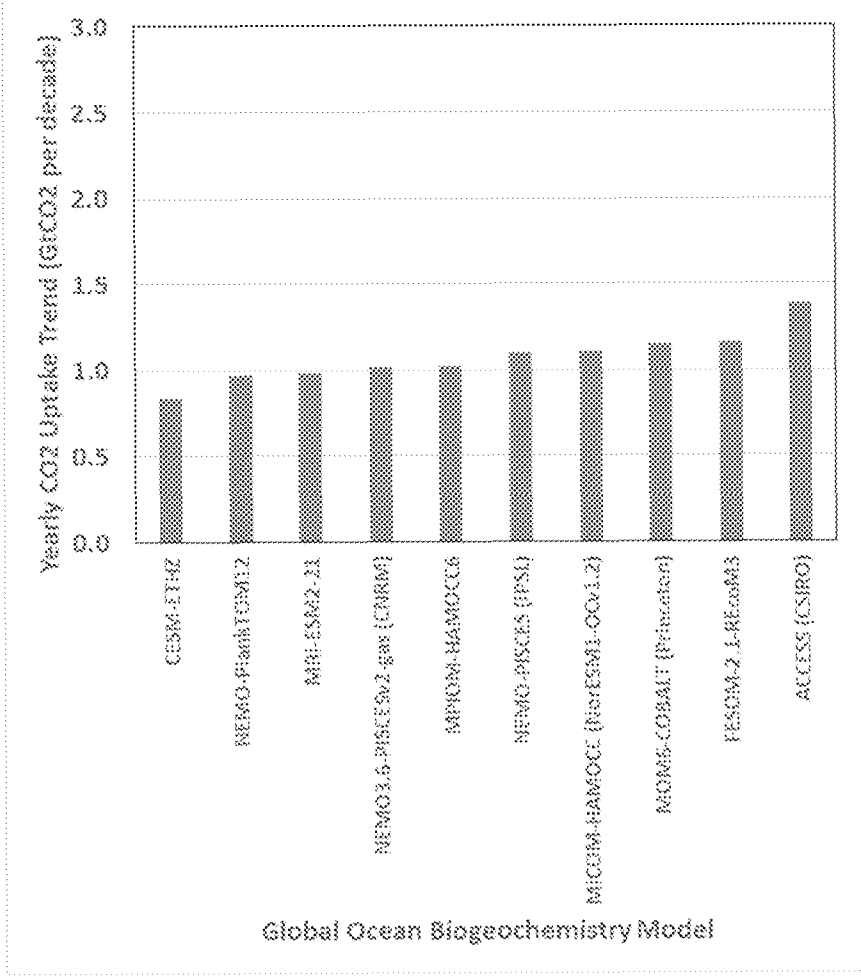


Figure 3.3.5 Decadal trends in the yearly CO₂ uptake by ocean processes during 1959-2023 simulated by 10 different ocean biogeochemistry models periodically reported by the Global Carbon Project (Friedlingstein, 2024).

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PART II: CLIMATE RESPONSE TO CO₂ EMISSIONS

4 CLIMATE SENSITIVITY TO CO₂ FORCING

Chapter Summary

There is growing recognition that climate models are not fit for the purpose of determining the Equilibrium Climate Sensitivity (ECS) of the climate to increasing CO₂. The IPCC has turned to data-driven approaches using historical data and paleoclimate reconstructions, but their reliability is diminished by data inadequacies.

Data-driven ECS estimates tend to be lower than climate model-generated values. The IPCC AR6 upper bound for the likely range of ECS is 4.0°C, lower than the AR5 value of 4.5°C. This lowering of the upper bound seems well justified by paleoclimatic data. The IPCC AR6 lower bound for the likely range of ECS is 2.5°C, substantially higher than the AR5 value of 1.5°C. This raising of the lower bound is more weakly justified. Evidence since the AR6 finds the lower bound of the likely range to be around 1.8°C.

4.1 Introduction

The climate’s response to increasing concentrations of CO₂ is central to the scientific debate on anthropogenic climate change, and so also to the public debate on “climate action.” The simplest measure of that response is the rise in the global average surface temperature, quantified by the Equilibrium Climate Sensitivity (ECS). ECS is defined as the amount of warming expected in response to a doubling of CO₂ from its pre-industrial concentration of 280 ppm, after all climate components have had time to adjust. Some components, like temperatures in the lower atmosphere (troposphere), adjust rapidly, while others such as the deep ocean and cryosphere might take as long as centuries. A related measure, the Transient Climate Response (TCR), better describes the shorter time scales; it is defined as the amount of warming when the CO₂ concentration is doubled by rising one percent annually for 70 years.

The 1979 Charney Report for the US National Academy of Sciences (Charney *et al.* 1979) proposed that the most likely ECS was 3.0 ± 1.5°C. The IPCC repeatedly reaffirmed that range with only minor variations until its most recent AR6. AR5 termed 1.5–4.5°C as the *likely* range (66 percent probability) and stated that ECS is *extremely unlikely* (95 percent probability) to be below 1.0°C and very unlikely (90 percent probability) to exceed 6.5°C.

The uncertainty in ECS has remained stubbornly wide, despite many individual studies that claimed to narrow it. Most recently, AR6 narrowed the *likely* range to 2.5–4.0°C and deemed the *very likely* range to be 2.0–5.0°C. This narrowing on the low end is disputed, as will be discussed below.

Uncertainties in ECS are highly consequential for policy making. As will be discussed in Chapter 11, economic models use ECS values to project the costs of CO₂ emissions. The traditional value (3.0 °C) has typically yielded modest global social costs of CO₂ emissions, sufficient to justify some policy actions, but mostly deferred to later in this century. If ECS is very high (above 4.5°C) immediate aggressive emission controls become more imperative, whereas no CO₂ emission controls are economically justifiable for ECS below 2.0°C (Dayaratna et al. 2016, 2020). Obtaining a precise estimate is impossible, so policy making needs to account for the uncertainty.

Climate scientists use multiple lines of evidence to determine the Equilibrium Climate Sensitivity:

- Climate model simulations
- Historical observations
- Paleoclimatic observations

- Process understanding of feedbacks

By itself, the equilibrium warming effect of a doubling of atmospheric CO₂ is slightly more than 1°C (Soden and Held 2006). Larger values of ECS arise from positive feedbacks that amplify the CO₂ warming. Water vapor feedback is positive: a warmer atmosphere may have more water vapor, which itself is a powerful greenhouse gas. Warmer temperatures also result in less snow and sea ice cover, allowing the Earth to absorb more of the sun’s radiation. Some simple estimates of these feedbacks increase the ECS to around 2°C (Sherwood et al., 2020).

Values of ECS above 2°C arise primarily from positive cloud feedbacks whose magnitude, and even sign, are highly uncertain. Elements of cloud feedback include changes in the latitudinal distribution of clouds, changes in the distribution of cloud height (changes in low versus high clouds), changes to the phase of clouds (ice versus liquid), changes in cloud particle size (associated with changes in concentration and/or composition of aerosol particles), changes in the precipitation efficiency of clouds, and even changes in how clouds are distributed over the daily solar cycle (Curry and Webster, 1999). It is difficult for climate models to simulate any of these processes correctly owing to their small scale, let alone predict how they will change in the future. Further, cloud processes modulate the magnitudes of the water vapor, lapse rate, and the surface albedo feedbacks.

4.2 Model-based estimates of climate sensitivity

The ECS ranges given in IPCC AR4 and AR5 were obtained primarily by examining the behaviour of large-scale climate models, also called General Circulation Models (GCMs). However, the IPCC changed course in its AR6 when it turned to a more direct data-driven methodology. Here we discuss some of the pitfalls of using GCMs to try to determine the Earth’s climate sensitivity.

ECS is an emergent property of climate models—that is, it is not directly parameterized or tuned. Historically, collections of parameterizations have been chosen to produce an expected value of climate sensitivity, particularly with regards to sub-grid-scale cloud processes, particularly in AR4 and to a lesser extent in AR5. Otherwise plausible GCMs and parameter selections have been discarded because of perceived conflict with this warming rate, or aversion to a model’s climate sensitivity being outside an accepted range. For example, even in a CMIP6 model, Mauritsen and Roeckner (2020) state the following regarding their Max Planck Institute climate model (emphasis added):

“We have documented how we tuned the MPI-ESM1.2 global climate model to match the instrumental record of warming; an endeavor which has clearly been successful. Due to the historical order of events, the choice was to do this practically by *targeting an ECS of about 3 K using cloud feedbacks*, as opposed to tuning the aerosol forcing.”

In other words, the modelers chose an ECS value of 3°C and then tuned the cloud parameterizations to match their intended result.

Direct warming from CO₂ doubling is only about 1°C (Hall and Manabe 1997); further warming arises from climate feedbacks that are not explicitly resolved by the GCM but rely on parameterizations of physical processes. Higher values of ECS arise primarily from assumed positive cloud feedbacks, whereas the magnitude and even the sign of the feedbacks are very uncertain. Elements of cloud feedback include changes in the latitudinal distribution of clouds, changes in the distribution of cloud height (changes in low versus high clouds), changes to the phase of clouds (ice versus liquid), changes in cloud particle size (associated with changes in concentration and/or composition of aerosol particles), changes in the precipitation efficiency of clouds, and even changes in how clouds are distributed over the daily solar cycle

(Curry and Webster, 1999). It is difficult for GCMs to simulate any of these processes correctly owing to their small scale, let alone predict how they will change in the future. Further, cloud processes modulate the magnitudes of the water vapor, lapse rate, and the surface albedo feedbacks.

ECS can be determined from climate model simulations by doubling the concentration of CO₂ and allowing several centuries for the warming to equilibrate. To avoid the necessity of long simulations, “effective climate sensitivity” is commonly evaluated from a 150-year simulation in response to a sudden quadrupling of CO₂.

The spread of ECS values from the CMIP5 ensemble of climate models used in the AR5 was 2.0–4.7°C; that range increased for the CMIP6 models used in the AR6 to between 1.8 and 5.7°C (Chen et al., 2021, Scafetta 2021, see Figure 5.1). Far from settling the model-based sensitivity of climate system uncertainties appear to be growing. The main cause of the overall upward shift in ECS in CMIP6 relative to CMIP5 is a larger positive cloud feedback, driven by changes to the cloud parameterizations in many CMIP6 models (Zelinka et al., 2020)

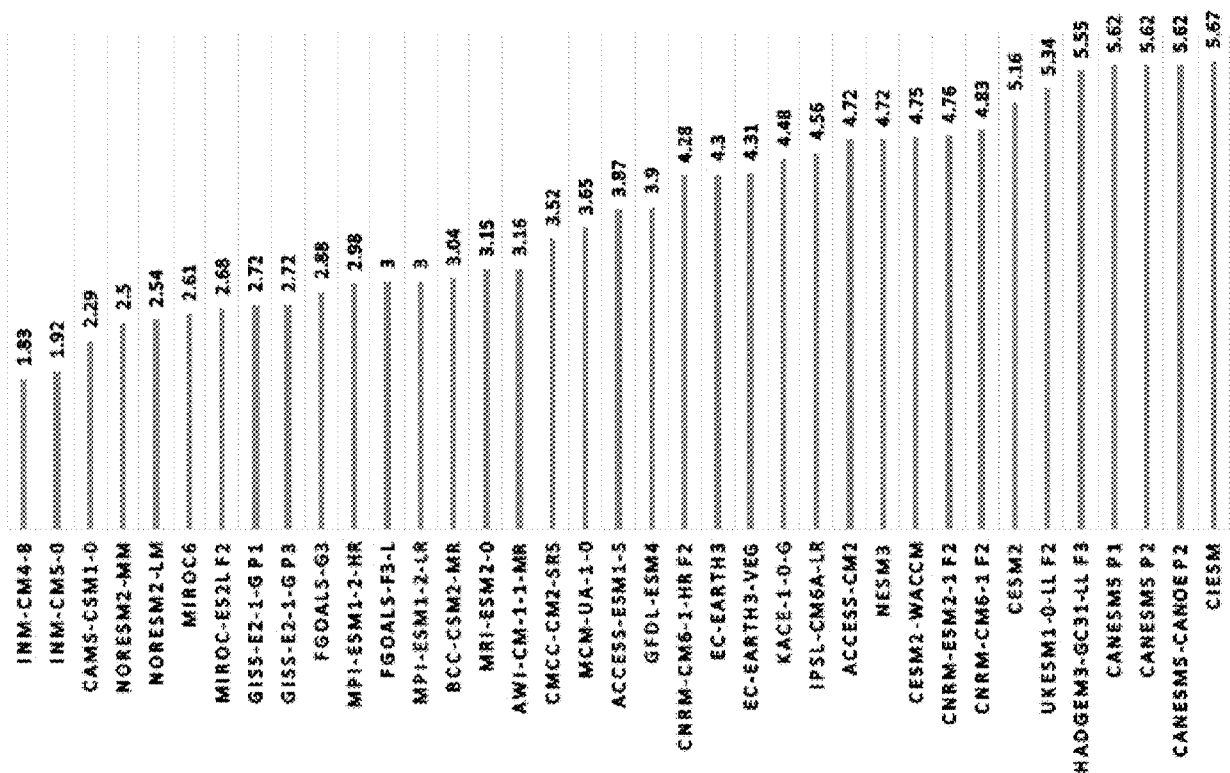


Figure 4.1 Equilibrium Climate Sensitivities in °C of 37 climate models from the CMIP6 ensemble. Identifiers for the various models appear along the horizontal axis. From (Scafetta, 2021) <https://www.mdpi.com/2225-1154/9/11/161>

Because of concerns about model tuning and the high sensitivity to cloud parameterizations, the IPCC AR6 (2021) did not rely on climate model simulations in their assessment of climate sensitivity, relying instead on other methods, chiefly a recent empirical estimate.

4.3 Data-driven estimates of climate sensitivity

Climate sensitivity can also be estimated from instrumental records of surface temperatures and ocean heat content, combined with estimates of how climate forcings (e.g., greenhouse gases, solar, volcanoes, aerosols) have changed in the past (Otto et al., 2013). Using this information, a simple empirical model called an Energy Balance Model can be employed. It requires estimating a feedback parameter whose uncertainties are highly amplified in the resulting ECS (Roe and Baker, 2007).

The accuracy of the data-driven methods depends on the quality of the input data. Assumptions are needed about ocean heat storage, and the ocean data is inadequate. The greatest source of uncertainty is the amount and composition of aerosol particles and their interactions with cloud radiative properties (the so-called aerosol indirect effect). Climate models exhibit warming in response to GHGs but cooling in response to aerosols (Schwartz et al., 2007). Observed 20th century warming can be shown to be consistent either with low ECS and low aerosol cooling, or high ECS and high aerosol cooling. Since fossil fuel use adds both GHGs and aerosols to the atmosphere, both effects need to be estimated to isolate the warming effect of CO₂. Over time, the IPCC’s estimate of the cooling effect of aerosols has declined (Lewis, 2022).

Paleoclimate proxies are also used to evaluate the sensitivity of past climates, by comparing paleoclimate changes in the Earth’s temperatures to estimates of changes in forcings. The two most informative periods are the last glacial maximum (around 20,000 years ago), which was about 3–7°C colder than today, and a mid-Pliocene period (roughly three million years ago), which was 1–3°C warmer than today. The limits on cooling during the last glacial maximum give the best single evidence that high values of climate sensitivity are unlikely. However, paleoclimate estimates are associated with very large uncertainties in the estimated temperatures and forcings. Further, estimates of climate sensitivity based on past climate states may not be representative of the current state of the climate system.

A recurring theme in the climate literature is that ECS estimates based on historical data are smaller than ECS estimates inferred from climate models (Sherwood and Forest 2024). About 15 estimates based on historical data appeared in the peer-reviewed literature between 2012 and 2024 yielding ECS best estimates between 1.0°C and 2.5°C, although critics have questioned some of the methods and the data quality. For the AR6, the IPCC placed primary weight on the results of Sherwood et al. (2020) that combined historical and paleoclimate proxies with the process-based approach and yielded a best estimate of 3.1°C with a *likely* range of 2.6–3.9°C. Lewis (2022) raised a number of concerns about this result, including methodological errors, outdated input values, and use of subjective versus objective Bayesian priors in the analysis. Lewis’ analysis found that climate sensitivity is estimated to be much lower and better constrained than in the Sherwood et al. analysis – median 2.2°C (1.8–2.7°C in the 17–83 percent *likely* range, and 1.6–3.2°C in the 5–95 percent *very likely* range). The IPCC AR6 estimated only a 5 percent probability that ECS was below 2.3°C, whereas Lewis estimated it to be over 50 percent. The most recent publications on the debate between Sherwood et al. and Lewis further defend their respective positions: Sherwood and Foster (2024) and Lewis (2025).

An argument emphasized in AR6 is that data-driven ECS estimates might understate the future warming response to GHGs because of a so-called “pattern effect” (Forster et al., 2021). The tropical Pacific is believed to strongly influence the overall efficiency with which the Earth radiates heat to space, but some regions remove heat more efficiently than others. If the west-to-east temperature gradient in the tropical Pacific is weakened in a warming climate, warming would concentrate where heat is less efficiently removed, raising ECS.

Most climate models simulate that rising GHGs will weaken the east-west temperature gradient, which led the IPCC in the AR6 to conclude that data-driven ECS estimates understated the *future* ECS value. However, Seager et al. (2019) pointed out that, contrary to models, the east-west temperature gradient has been strengthening over time. They further argued that the mechanism predicting otherwise in climate models was based on a faulty characterization of oceanic dynamics and there is no reason to expect the gradient to weaken. A similar argument was recently made by Lee et al. (2024), who concluded that “the

trajectory of the observed trend reflects the response to increasing GHG loading in the atmosphere”; in other words, GHG warming should lead to a future strengthening rather than a weakening of the temperature gradient. Increased efficiency of atmospheric cooling implies, if anything, that the future ECS in a warming climate may be *lower* than current estimates.

4.4 Transient Climate Response

The Transient Climate Response (TCR) provides a more useful observational constraint on climate sensitivity. TCR is the amount of warming that results when CO₂ is increased at an annual rate of 1 percent over a period of 70 years (i.e., doubled gradually). Relative to the ECS, observationally determined values of TCR avoid the problems of uncertainties in ocean heat uptake and the fuzzy boundary in defining equilibrium arising from a range of timescales for the longer-term feedback processes (e.g., ice sheets). TCR is more generally related to peak warming and better constrained by historical warming, than ECS. IPCC AR6 judged the *very likely* range of TCR to be 1.2–2.4°C. In contrast to ECS, the upper bound of TCR is more tightly constrained. For comparison, the TCR values determined by Lewis (2023) are 1.25 to 2.0°C, showing much better agreement with the AR6 values than was seen in a comparison of the ECS values.

As will be discussed in Chapter 6, a real-world ECS smaller than the model average is supported by studies that show climate models on average overestimate the observed surface and troposphere warming over the past 50 years. Lower sensitivities also align with evidence from consistent fingerprinting (Section 8), where model responses need to be downscaled to align with observed trends.

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5 MODELS VERSUS OBSERVATIONS IN THE RECENT PAST

Chapter summary

Climate models show warming biases in many aspects of their reproduction of the past few decades. In response to observed changes in forcing inputs they produce too much warming at the surface (except in the models with lowest ECS), too much warming in the lower-and mid-troposphere and too much amplification of warming aloft.

Climate models also produce too much recent stratospheric cooling, too much water vapor increase, too much snow loss, and too much warming in the corn belt. The IPCC has acknowledged some of these issues but not all.

5.1 Introduction

Climate models are the primary tool used to project future climate changes in response to increasing atmospheric levels of anthropogenic greenhouse gases. They provide theoretical evidence underpinning energy policy changes, such as efforts to reduce carbon dioxide emissions. To assess the fitness of climate models for this purpose, it is reasonable to ask how well they reproduce the current climate and its variations over the past century. The nearby box “Climate modeling” gives some detail on how climate models work.

Of great concern is the fact that, after several decades of the climate modeling enterprise involving approximately three dozen models operated by research centers around the world, the range of future warming they produce in response to a hypothetical doubling of atmospheric CO₂ extends over a factor of three, as we discussed in the previous chapter. This range of disagreement among models has not changed for decades.

Problems with climate models are not just in their disagreement over the future, but also in their ability to replicate the recent past. Here we review some of the most important metrics of climate model accuracy: ability to reproduce historical surface, tropospheric and stratospheric temperature trends, ability to reproduce the vertical warming profile and ability to reproduce other climate features such as snowfall and humidity. In all cases a persistent finding is that models on average err on the side of too much warming in response to observed historical forcings.

Box: Climate modeling

Most climate models, except for the simplest ones, represent Earth's land surface using a grid of squares, typically 100 km wide. To simulate the atmosphere, 10 to 20 layers of grid boxes are stacked above these squares. The ocean is modeled using a similar but finer grid, resulting in approximately one million grid boxes for the atmosphere and 100 million for the ocean.

The computer models, based on physical laws, calculate how air, water, and energy move between grid boxes over time. The time step can be as small as 10 minutes, and repeating this process millions of times allows the simulation of climate over centuries. Running these models, even on the most powerful supercomputers, can take months. Comparing simulation results with historical climate data helps assess the accuracy of a model, while projections into the future estimate climate changes under assumed human and natural influences.

Despite sounding straightforward, climate modeling is highly complex. Many critical processes occur at scales smaller than the 100 km grid size. For instance, the flows of sunlight and heat in the atmosphere depend strongly on cloud cover. Since tracking individual clouds is impractical, researchers must make "subgrid" assumptions about the distribution of clouds in each grid box. Snow and ice cover, which affects how much sunlight is reflected or absorbed by the surface, is another subgrid factor.

Each subgrid assumption requires numerical parameters, which must be carefully set. Modelers initially estimate these parameters based on physics and observed climate patterns, then run the model. Because early results often diverge significantly from real-world observations, they "tune" these parameters to better match observed climate features. Different modeling teams use distinct assumptions and tuning strategies, leading to varied outcomes. Tuning is a necessary but delicate aspect of climate modeling, as it is in any complex system. Poor tuning can result in inaccurate simulations, while excessive tuning risks artificially steering results toward predetermined conclusions.

To distill useful insights from these varied models, climate studies often rely on averaged results from multiple models, forming an "ensemble." The latest UN IPCC assessments use the CMIP6 ensemble, which shows a significant diversity of results. One of the most basic climate indicators—the Earth's average surface temperature—varies by about 3°C across the ensemble, three times greater than observed warming during the 20th century.

Although model success in reproducing some features of today's climate is reassuring, the critical issue for society is how well they predict responses to subtle human influences, such as greenhouse gas emissions, aerosol cooling, and land-use changes. The most crucial aspect models must capture correctly is "feedbacks." These occur when climate changes triggered by greenhouse gases either amplify or suppress further warming. For example, as global temperatures rise, snow and ice melt, reducing Earth's reflectivity. With less reflective surfaces, the planet absorbs more sunlight, leading to additional warming. Other significant feedbacks involve water vapor levels, cloud formation, and atmospheric temperature profiles. Based on ensemble averages, the net effect of all feedbacks is estimated to double or triple the direct warming impact of CO₂.

5.2 Surface warming

A straightforward test of a climate model's validity is its ability to reproduce historical warming in response to known past changes in climate drivers such as greenhouse gases. Figure 5.2 is reproduced from Scaffeta (2023), a peer-reviewed study that groups the latest-generation (CMIP6) climate models into low ECS (1.5 to 3.0 degrees C), medium ECS (3.0 to 4.5 degrees C) and high ECS (4.5 to 6.0 degrees C), and compares their post-1980 global average temperature simulation ranges to those of three surface temperature records and one satellite-based lower troposphere temperature data product.

The leftmost column shows that the low-ECS models track the post-1980 historical warming record reasonably well, but the middle and right columns show that the medium- and high-ECS models conspicuously over-predict the warming.

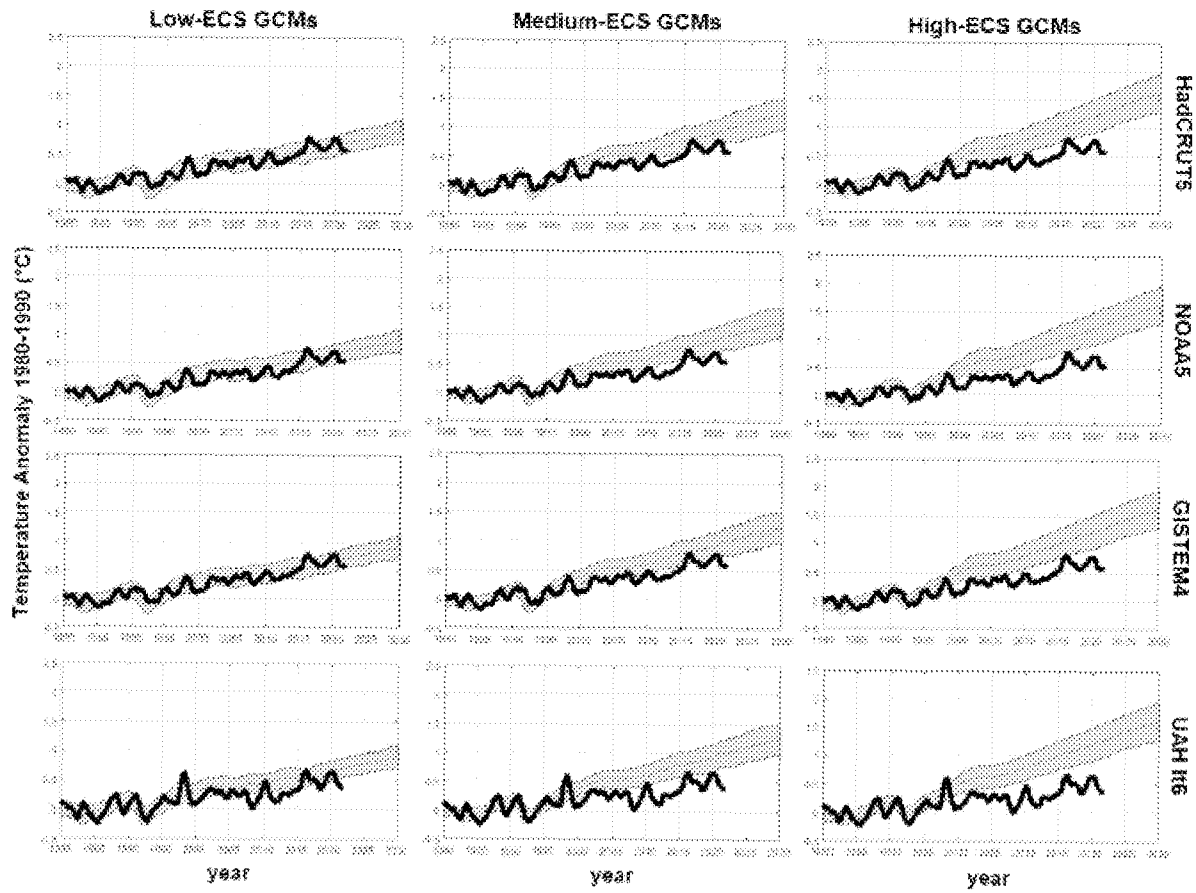


Figure 5.2: model-observational comparisons for Earth’s surface warming. The columns correspond to model groups showing low-ECS to high-ECS, while the rows correspond to widely-used observed temperature records, the first three showing surface averages and the fourth showing the lower troposphere average. In each panel the yellow area denotes the mean and range ($\pm$ one standard deviation) of climate model simulations for that group. The thick black line shows the observed annual average temperature in the indicated source. Source: Scafetta N. Climate Dynamics 2023 Fig.2.

Spencer (2024) has also provided a useful summary of the Model-Observation mismatch by comparing trends in surface temperature data products with those in individual climate models, as summarized in Figure 5.3.

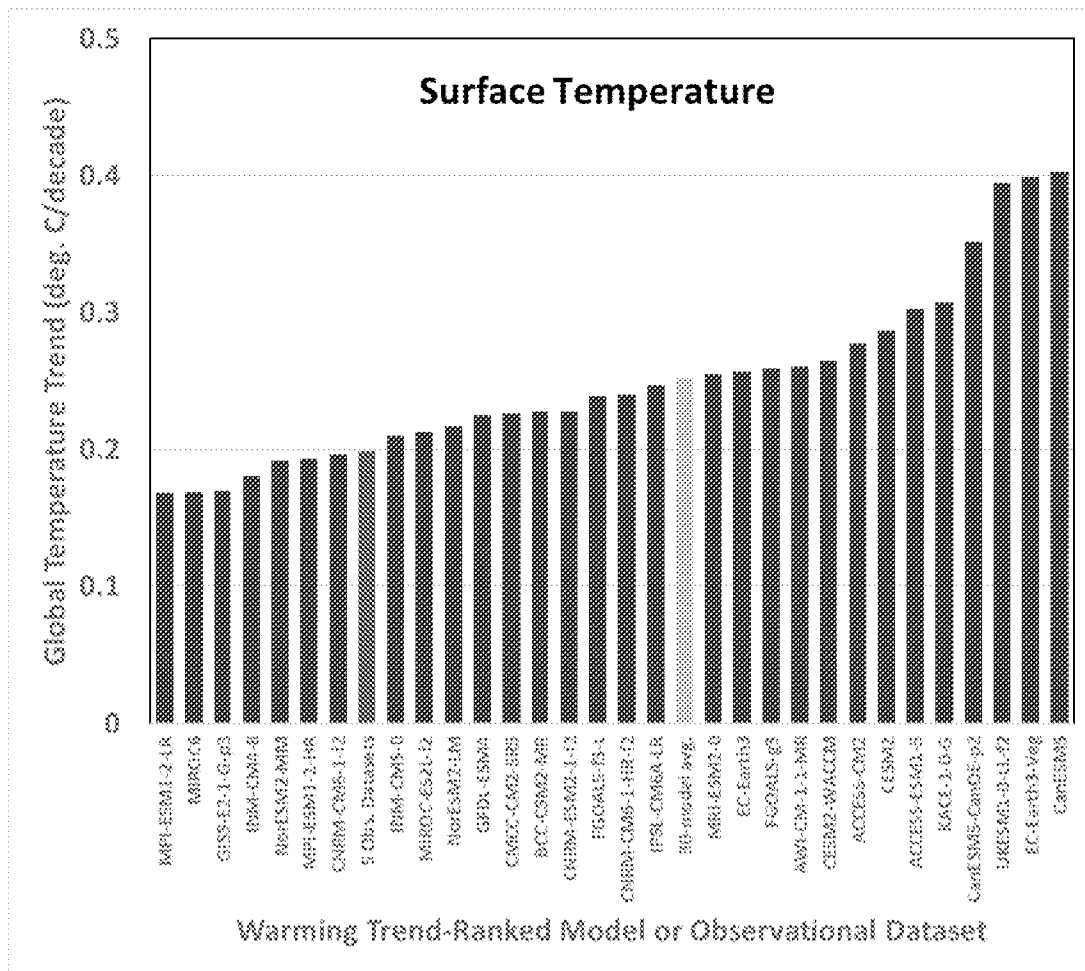


Figure 5.3 Global surface air temperature trends (°C/decade), 1979-2024, from various CMIP6 climate models (red, 30-model average in orange); and the average of three thermometer datasets (HadCRUT5, NOAA Global Temp, and Berkeley 1 deg.) and two reanalysis datasets (ERA5 and NCEP/NCAR R1) in blue.. Source: Spencer (2024) updated

5.3 Tropospheric warming

It has long been known that climate models on average overstate warming in the tropical troposphere. This region is an important test of the models since it has long been hypothesized that this is where the signal of anthropogenic greenhouse warming emerges first and most strongly. Biases in tropospheric trends indicate model flaws in heat transfer processes and carry over to surface warming biases.

The discrepancy was flagged as a serious inconsistency in the first US Climate Change Science Program report (Karl et al. 2006) and has been mentioned in every IPCC report since, but it has gotten worse over time, and the bias is now global. McKittrick and Christy (2020) compare tropospheric warming trends in CMIP6 climate models to observed trends from satellites, weather balloons and reanalysis systems. Figure 5.4 presents the comparisons with data updated to 2024. Every model overpredicts the average observed warming trend in both Lower- and Mid-Troposphere layers, both globally and in the tropics. In most individual models the bias is statistically significant and on average across models it is highly significant. McKittrick and Christy (2020) also show that the bias is larger in high-ECS models, but

even the models with lower average ECS predict too much warming. If future climate models were to realistically represent global tropospheric warming, they would likely be less sensitive than even the low-ECS members of the CMIP6 ensemble

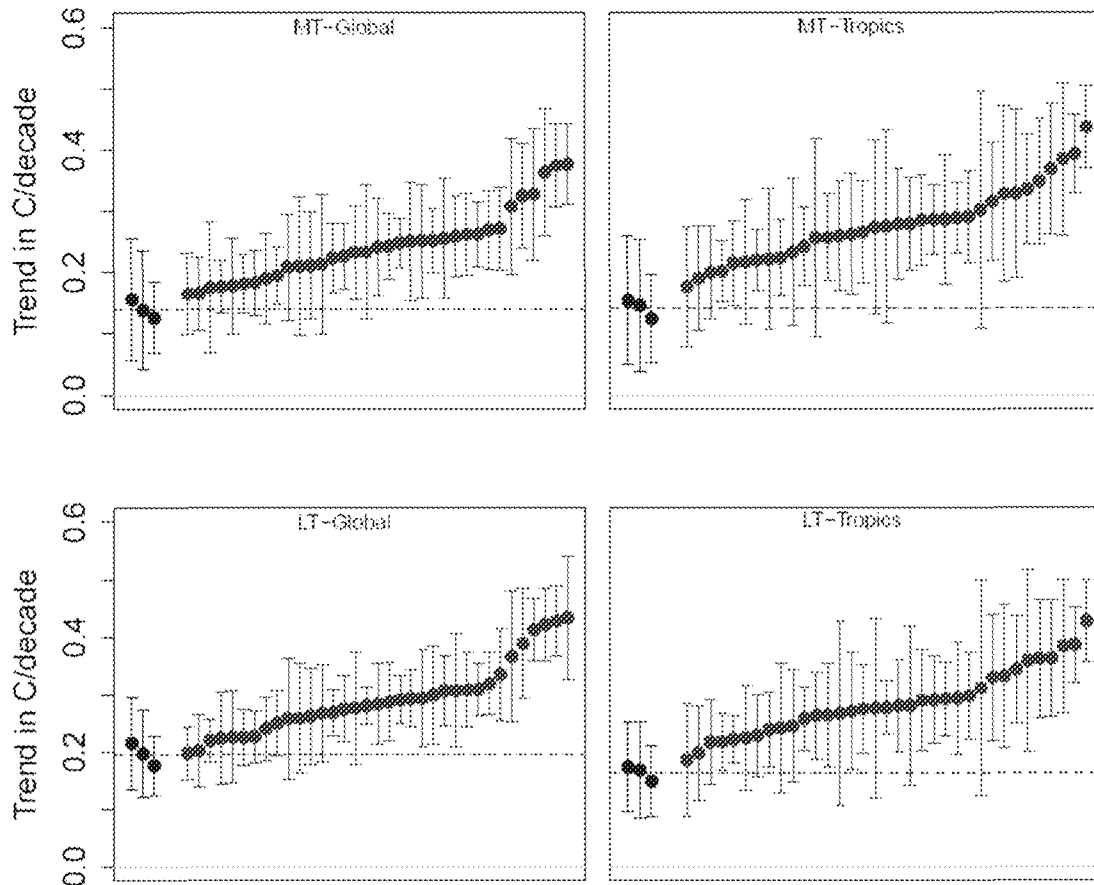


Figure 5.4: Observed versus CMIP6 modeled warming trends (°C/decade 1979-2024) in the global and tropical lower (LT) and mid-troposphere (MT). Uses methodology of McKittrick and Christy (2020) on updated data. Blue dots: warming trends with 95% confidence interval bars for 3 data products (radiosondes, reanalysis and satellites) and 95% confidence interval bars. Blue dashed line: warming trend average for 3 observed series. Red dots: modeled warming trends in 35 models arranged lowest to highest.

As mentioned the IPCC has long acknowledged the model-observation mismatch. For example AR6 pp. 443-444 offers this on the tropical troposphere (it does not address the global comparison):

Several studies since AR5 have continued to demonstrate an inconsistency between simulated and observed temperature trends in the tropical troposphere, with models simulating more warming than observations (Mitchell et al., 2013, 2020; Santer et al., 2017a, b; McKittrick and Christy, 2018; Po-Chedley et al., 2021)... Over the 1979–2014 period, models are more consistent with observations in the lower troposphere, and least consistent in the upper troposphere around 200 hPa, where biases exceed 0.1°C per decade. Several studies using CMIP6 models suggest that

differences in climate sensitivity may be an important factor contributing to the discrepancy between the simulated and observed tropospheric temperature trends (McKittrick and Christy, 2020; Po-Chedley et al., 2021), though it is difficult to deconvolve the influence of climate sensitivity, changes in aerosol forcing and internal variability in contributing to tropospheric warming biases (Po-Chedley et al., 2021). Another study found that the absence of a hypothesized negative tropical cloud feedback could explain half of the upper troposphere warming bias in one model (Mauritsen and Stevens, 2015).

... In summary, studies continue to find that CMIP5 and CMIP6 model simulations warm more than observations in the tropical mid- and upper-troposphere over the 1979–2014 period (Mitchell et al., 2013, 2020; Santer et al., 2017a, b; Suárez-Gutiérrez et al., 2017; McKittrick and Christy, 2018), and that overestimated surface warming is partially responsible (Mitchell et al., 2013; Po-Chedley et al., 2021). Hence, we assess with *medium confidence* that CMIP5 and CMIP6 models continue to overestimate observed warming in the upper tropical troposphere over the 1979–2014 period by at least 0.1°C per decade,

Notably, despite the accumulation of evidence of excess model warming the IPCC only assigns *medium confidence* to the existence of a warming bias.

5.4 Vertical profile mismatch and excess amplification

Another important model-observational discrepancy is the excess amplification with altitude found in climate models. The comparison was in the IPCC AR5 Chapter 10, although only in the online supplement (Figure 10.SM.1) and only in a figure the formatting of which made the point difficult to see. Figure 10.SM.1 is not referenced in the main IPCC report nor in any summary so readers would not have been aware of it. Although not apparent at first glance, it shows that the 1979-2010 warming in the lower troposphere is so small as to be consistent with no GHG forcing at all, and is inconsistent with the model runs that do have GHG forcing. In Figure 5.6 we adapt IPCC AR5 Figure 10.SM.1 to draw out the critical point.

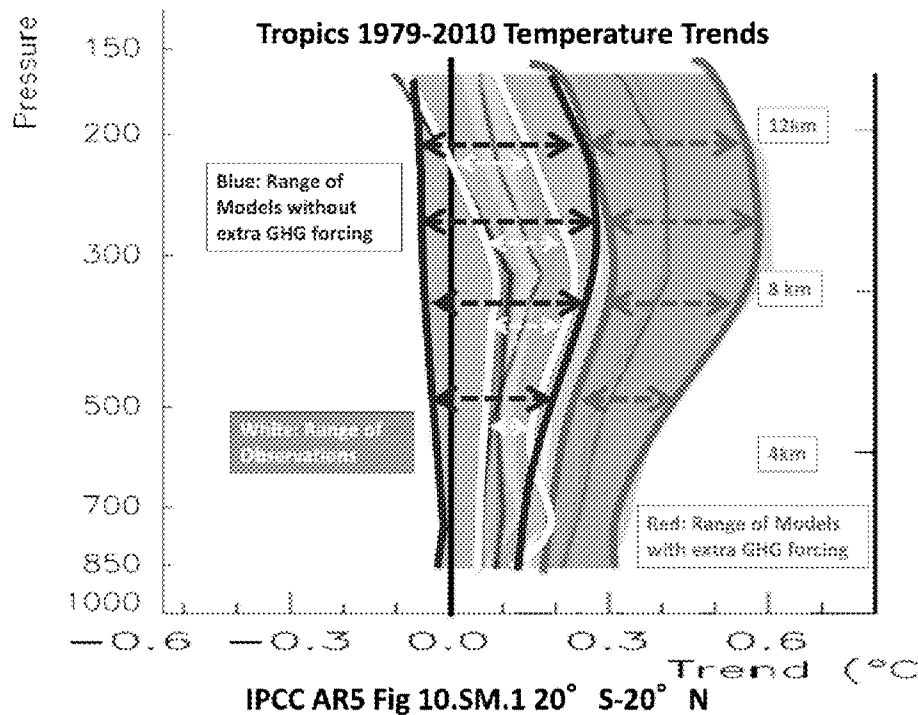


Figure 5.6: Vertical warming pattern for tropics (20S to 20N). Source: Annotated version of IPCC AR5 Figure 10.SM.1

Figure 5.6 compares temperature trends by altitude between models and observations between 20S and 20N (the tropics). In this region where the models say the warming should be strongest, the observations (shown here in white) lie within the “No CO₂” band and entirely outside the “with CO₂” red envelope. This means that in the entire tropical atmospheric column from the surface to the stratosphere, *observed warming trends are so small they are consistent with the output of models that have no CO₂ warming effect in them, and they are inconsistent with the entire envelope of warming trends generated by models forced with increased CO₂.*

A similar comparison is shown in Christy and McNider (2017), an updated version of which (covering 1979-2024) is reproduced as Figure 5.7. Modeled temperature trends exceed observations from the surface through the top of the troposphere, with observed trends below the entire model range at most pressure levels. Also shown in Figure 5.7 is the tropical tropospheric temperature (TTT) average from three satellite data products (NOAA, UAH and RSS) compared to the same layer average from climate models for 1979-2024. Again the observed trends lie below the entire model range.

The wide range of choices made by modelers to characterize the physical processes in the models (see Box: Climate Modeling in Section 5.1 above) is seen by the large spread of trends in the middle troposphere where values range over $\pm 40\%$ from the median value (Fig. 5.7). This illustrates the uncertainties characteristic of the varying attempts to model (parameterize) a complex system involving turbulence, moist thermodynamics and energy fluxes over the full range of time and space scales.

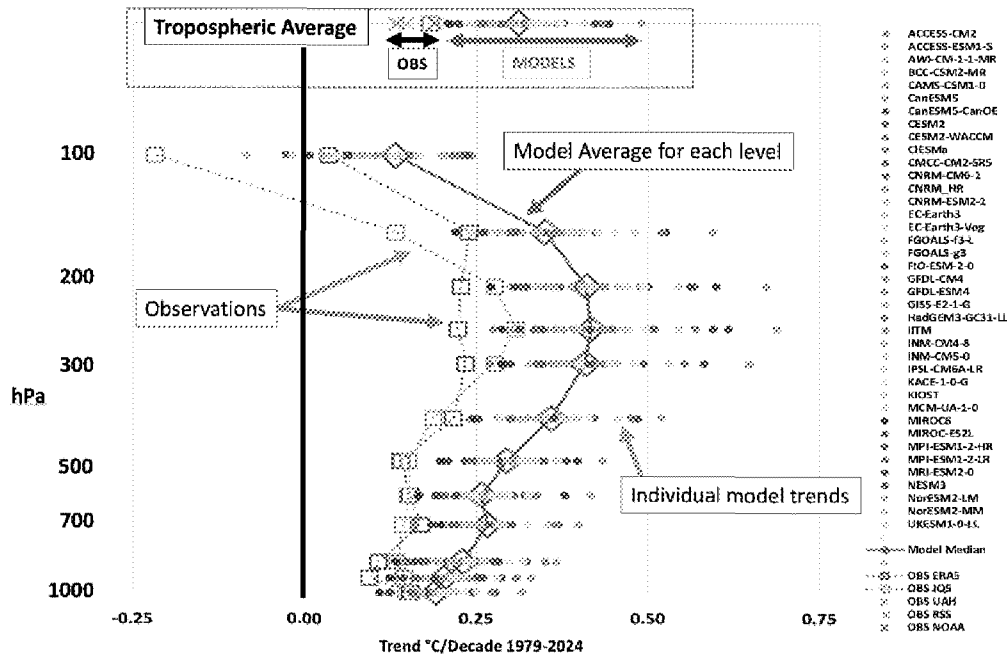


Figure 5.7: Modeled versus observed warming, tropical troposphere. Source: updated from Christy and McNider (2017) including data through 2024. Red line: model average. Green and blue lines: observational series (reanalysis).

This discrepancy has been the source of much controversy, with some arguing that even if there is very little observed warming aloft in the tropics, a “hotspot” still exists in the sense that the warming aloft is greater than at the surface. But there is good evidence that models also exaggerate the amplification rate. Klotzbach et al. (2009), showed that models project greater amplification with altitude than is observed. This result was subsequently confirmed by detailed time series analysis (Vogelsang and Nawaz 2016) who found that the model-observational difference is statistically significant.

This is a case in which models are not merely uncertain but share a common bias compared to observations. This suggests the representation of certain fundamental physical processes in climate model feedbacks have large discrepancies not only among models but against the real climate.

The IPCC AR6 did not assess this issue.

5.5 Stratospheric cooling

An important element of the expected general “fingerprint” of anthropogenic climate change is simultaneous warming of the troposphere and cooling of the stratosphere. The IPCC AR6 acknowledged that cooling had been observed but only up to the year 2000. Thereafter the stratosphere has exhibited some warming, contrary to model projections.

The AR6 WG1 Ch 2 pp. 327-9 states (emphasis added):

“Temperatures averaged through the full lower stratosphere (roughly 10–25 km) have decreased over 1980–2019 in all data products, with **the bulk of the decrease prior to 2000**. The decrease holds even if the influence of the El Chichon (1982) and Pinatubo (1991) volcanic eruptions on the trend, found by Steiner et al. (2020a) to have increased the 1979–2018 cooling trend by 0.06°C per decade, is removed. **Most datasets show no significant or only marginally significant trends over 2000–2019, and the results of Philipona et al. (2018) show weak increases over 2000–2015** in the very lowermost stratosphere sampled by radiosondes....

It is virtually certain that the lower stratosphere has cooled since the mid-20th century. However, most datasets show that **lower stratospheric temperatures have stabilized since the mid-1990s with no significant change over the last 20 years**. It is likely that middle and upper stratospheric temperatures have decreased since 1980, but there is low confidence in the magnitude.

The cited source, Philipona et al. (2018), in an article entitled “Radiosondes Show That After Decades of Cooling, the Lower Stratosphere Is Now Warming”, stated:

“In response to continued greenhouse gas increases and stratospheric ozone depletion, climate **models project continued tropospheric warming and stratospheric cooling** over the coming decades. Global average satellite observations of **lower stratospheric temperatures exhibit no significant trends since the turn of the century**. In contrast, an analysis of vertically resolved radiosonde measurements from 60 stations shows an increase of lower stratospheric temperature since the turn of the century at altitudes between 15 and 30 km and over most continents. Trend estimates are somewhat sensitive to homogeneity assessment choices, but all investigated **radiosonde data sets suggest a change from late twentieth century cooling to early 21st century warming in the lower stratosphere.**”

A combination of tropospheric warming and stratospheric cooling is a commonly-cited “fingerprint” of anthropogenic warming. Stratospheric warming since 2000 coincides with continued surface and tropospheric warming, a pattern that is not found in climate model simulations and is not apparently consistent with the anthropogenic fingerprint.

5.6 Snow cover mismatch

Data compiled by the Rutgers University Snow Lab (undated) show that Northern Hemisphere winter snow cover is not decreasing (Figure 5.8). If anything, it shows an increasing trend.

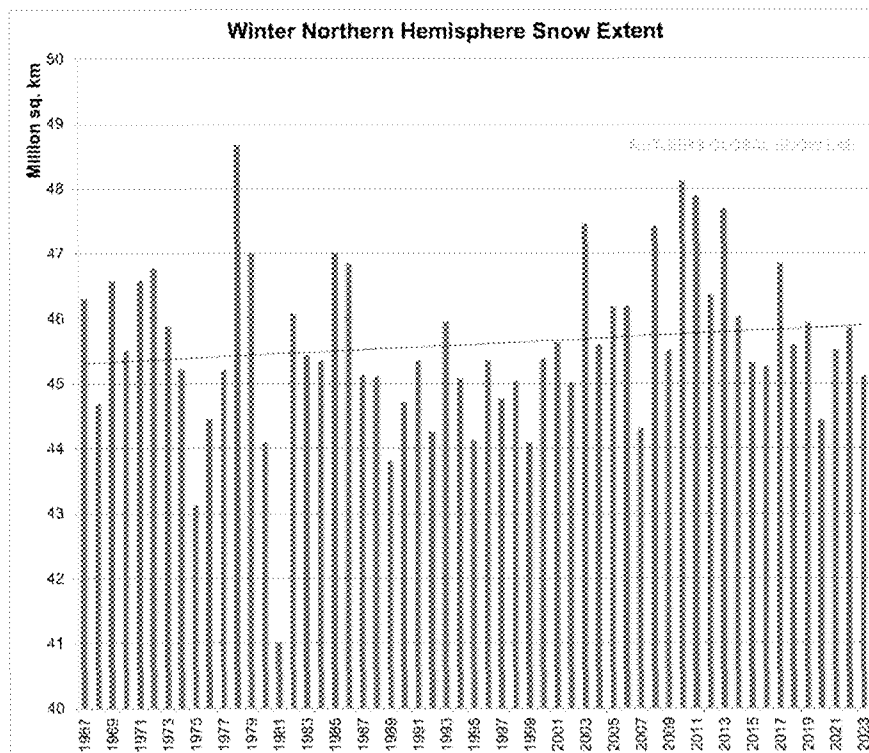


Figure 5.8: Northern Hemisphere Winter Snow extent.

Source: https://climate.rutgers.edu/snowcover/chart_seasonal.php?ui_set=nhland&ui_season=1
(February 24, 2024)

Yet models project declining Northern Hemisphere snow cover due to climate warming, as described by Connolly et al. (2019).

The climate models were found to poorly explain the observed trends [in Northern Hemisphere snow cover]. While the models suggest snow cover should have steadily decreased for all four seasons, only spring and summer exhibited a long-term decrease, and the pattern of the observed decreases for these seasons was quite different from the modelled predictions. Moreover, the observed trends for autumn and winter suggest a long-term increase, although these trends were not statistically significant.

Connolly et al. (2019).

AR6 largely confines its discussion of changing Northern Hemisphere snow cover extent (SCE) to the Spring season for which models and observations agree on a downward trend. Regarding Winter changes it remarks as follows (AR6 WGI Ch. 2 p. 344):

Assessment of SCE trends in the NH since 1978 indicates that for the October to February period there is substantial uncertainty in trends with the sign dependent on the observational product. Analysis using the NOAA Climate Data Record shows an increase in October to February SCE

(Hernández-Henríquez et al., 2015; Kunkel et al., 2016) while analyses based on satellite borne optical sensors (Hori et al., 2017) or multi-observation products (Mudryk et al., 2020) show a negative trend for all seasons.

AR6 WGI Chapter 9 (p. 1284) points out that the NOAA Climate Data Record showing increased fall and winter SCE is inconsistent with land-based observations and model-based data sets. It notes that using optical satellite imagery to infer SCE in winter is challenging due to cloud cover and decreased solar illumination in winter months.

Focusing on the Pacific Coast states (CA, OR and WA) cold season mountain snowfall that melts in spring and summer provides a substantial portion of warm season water resources. A comprehensive reconstruction of snowfall for the main source regions (Cascades and Sierra Nevada Mountains) indicates no significant trends in annual totals since the late 19th century (Christy 2022).

5.7 Hemispheric symmetry of the planetary albedo

The planetary albedo is the fraction of solar radiation reflected by the Earth back to space, and is an important component of the radiative balance and hence whether the planet will warm or cool over time. An intriguing property of the Earth's albedo is that, on average, the Northern Hemisphere (NH) and Southern Hemisphere (SH) have had very nearly the same albedo at least throughout the fifty-year satellite record (Stephens et al., 2015). This symmetry is surprising, because the SH has much more ocean than land. Since ocean is less reflective than land, the NH should have higher albedo. Clouds (which are highly reflective) are more common in the NH, and so compensate the surface albedo imbalances of the two hemispheres. Datseris and Stephens (2021) show that this cloud compensation comes from the extra-tropical storm tracks of the SH, which are cloudier than those of the NH. While the mechanism for this hemispheric symmetry is unclear, it likely operates on large temporal and spatial scales.

The hemispheric symmetry of the albedo is a simple gross metric for climate models. Rugenstein and Hakuba (2023) defined that metric as the difference between the NH and SH annual mean albedos, expressed as Wm^{-2} of the reflected sunlight, and compiled it for the CMIP6 climate models, as shown in Figure 5.9. Most of the CMIP6 models do not reproduce the small observed asymmetry (about 0.1 Wm^{-2}) and even disagree as to which hemisphere is more reflective. Moreover, the magnitude of the asymmetry ranges up to 5 Wm^{-2} in some models, twice as large as the current anthropogenic forcing (about 2.5 Wm^{-2}).

The significance of unphysical albedo asymmetries in the climate models is not yet fully known. However, other model studies suggest that interhemispheric changes in albedo can alter poleward heat fluxes, meridional temperature gradients, storminess, and differences in hemispheric ocean heat storage. The discrepancy between models and observations further raises issues regarding cloud feedback processes and so more generally diminishes confidence in model projections of the future climate.

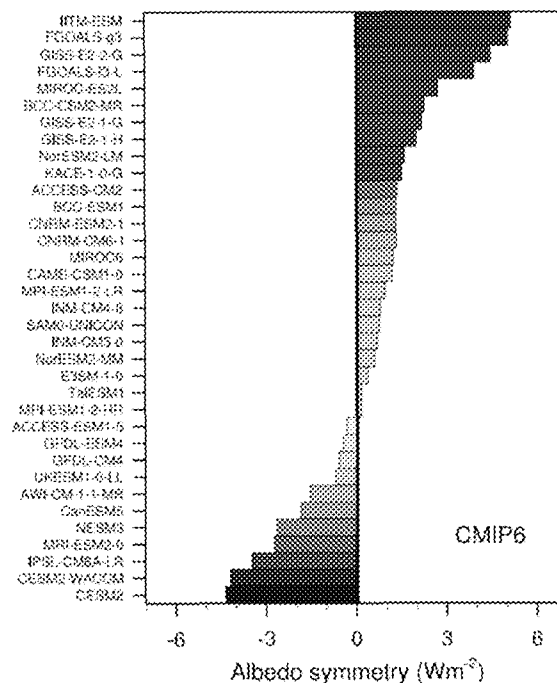


Figure 5.9. Differences in 20-year average reflectivity (albedo) between the Northern and Southern Hemispheres for CMIP6 models used in the most recent IPCC assessment (colored bars). The very small observed difference is indicated by the vertical black line. From Rugenstein and Hakuba (2023).

5.8 US Corn Belt

One of the largest discrepancies between models and observations is in the U.S. Corn Belt, a region of particular importance to global food production. Figure 5.10 shows the warming trends for summertime (June, July, August) for the 12-state Corn Belt (IN, IA, NE, ND, SD, MO, MN, WI, MI, OH, KS, NE) during 1973-2022. All 36 climate models (red) warm far too rapidly compared to observations (blue).

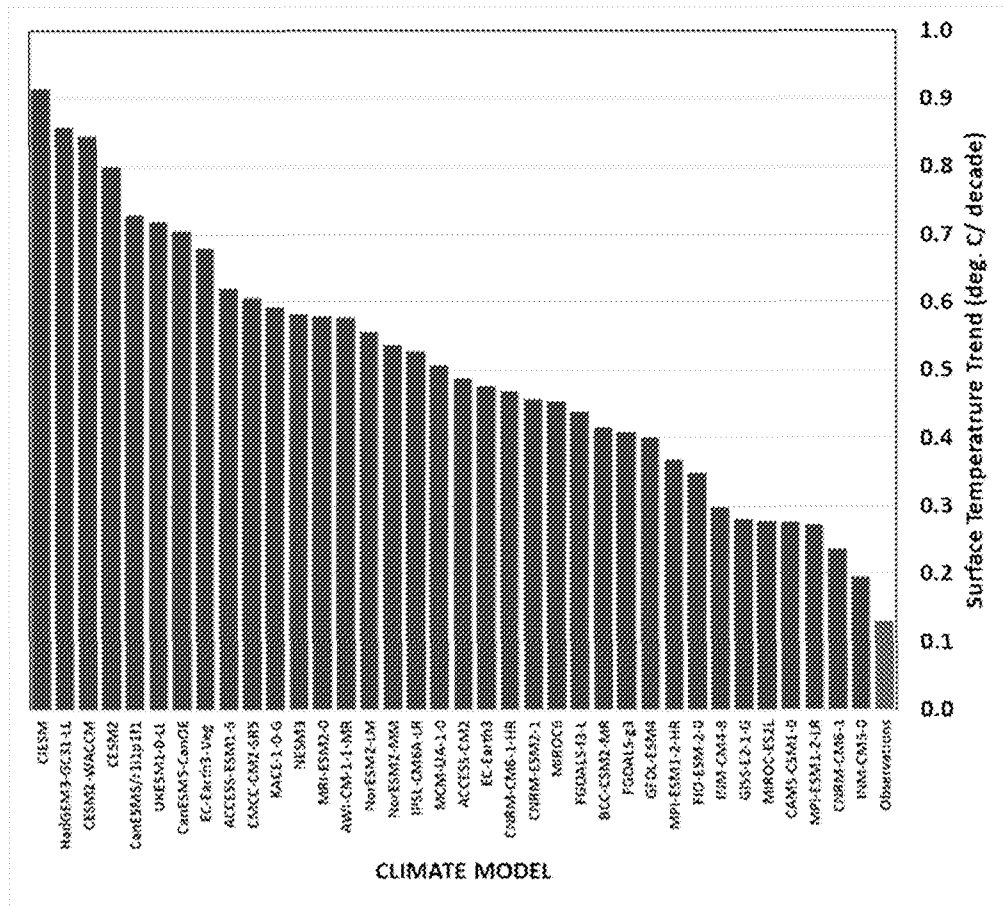


Figure 5.10: Modeled versus observed warming trends in the US corn belt.

As discussed in Chapter 10, the anticipated negative effects of increasing temperatures on U.S. corn yields have not materialized, in contrast to widely publicized studies proclaiming that theoretical future impacts are already being experienced (e.g. Seager et al., 2017).

The IPCC acknowledges limitations in the accuracy of regional climate model outputs. This example shows that users need to assess model projections carefully on a case-by-case basis since local biases may be sufficiently large that the models are simply not fit for purpose. As has recently been noted by two leaders of the modeling community (emphasis added)

... for many key applications that require regional climate model output or for assessing large-scale changes from smallscale processes, we believe that **the current generation of models is not fit for purpose.** (Palmer and Stevens 2019)

To summarize:

- Climate models show warming biases in many aspects of their reproduction of the past few decades.
- They produce too much warming at the surface (except in the models with lowest ECS), too much warming in the lower-and mid-troposphere and too much amplification of warming aloft

- They also produce too much stratospheric cooling, too much snow loss, and too much warming in the corn belt.
- The hemispheric albedo difference in individual climate models ranges widely in sign and magnitude compared to observations. The range in Watts/m² is three times larger than the direct anthropogenic forcing of CO₂.
- The IPCC has acknowledged some of these issues but not others.

References

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6 EXTREME WEATHER

Chapter Summary

Most types of extreme weather exhibit no statistically significant long-term trends over the available historical record. While there has been an increase in hot days in the US since the 1950s, a point emphasized by the IPCC AR6, numbers are still low relative to the 1920s and 1930s. Extreme convective storms, hurricanes, tornadoes, floods and droughts exhibit considerable natural variability but long-term increases are not detected. Some increases in extreme precipitation events can be detected in some regions over short intervals but over long periods and at the regional scale the trends do not persist. Wildfires are not more common in the US than they were in the 1980s. Burned area increased from the 1960s to the early 2000's however it is low compared to the estimated natural baseline level. US wildfire activity is strongly affected by forest management practices.

6.1 Introduction

High impact weather extremes, usually related to temperature, precipitation and/or high wind, can disrupt infrastructure and therefore endanger human health and wellbeing. The issue is not whether extremes occur. Rather, it is whether there are long-term (decadal scale) changes in the frequency or character of extremes (“detection”), as well as the extent to which such changes and the attendant changes in hazards are caused by anthropogenic emissions of greenhouse gases (“attribution”; e.g., IPCC AR6 Seneviratne et al. 2021).

It is naïve to assume that any recent extreme event is caused by human influences on the climate. Climate is about the statistical properties of weather over decades, not single events. And, there are only about 130 years of reliable observational records that can be analyzed statistically. That brief interval does not begin to contain all the extreme events that the climate system can create on its own. Over geologic time the climate system has generated an (essentially) infinite variety of weather patterns and extremes that humans have never observed and thus are absent from the databases used to determine extreme statistics [see *Perils of short data records* below]. For that reason, attributing an extreme event unprecedented in the record requires assumptions about the magnitude of natural variations.

This chapter is concerned with detection of trends in extreme weather, while Chapter 8 considers causal attribution, with Section 8.4 specifically addressing extreme weather. If no trend is detected, then clearly there is no basis for attribution. But even where a trend is observed, attribution should not be assumed to follow.

This is especially true for precipitation events. The hydrological literature has long noted the phenomenon of *Long-Term Persistence* (LTP) in rainfall data (Hurst 1951, Cohn and Lins 2005, Markonis and Koutsoyiannis 2015). LTP has a formal mathematical definition, but it can be thought of as the presence of natural variations with strong autocorrelations that result in cycle-like behavior on long time scales. The presence of LTP requires long records to accurately estimate variability. Analysis of records that are short relative to the LTP scale will tend to underestimate variability, therefore overstating the significance of apparent trends and underestimating the likelihood of extreme events (Cohn and Lins 2005).

A good example of LTP is the eight-century long record of the annual minimum height of the Nile River observed at Roda Island in Cairo shown in Figure 6.1.1. Since human influences on the global climate were negligible before the 20th century, the century-scale variability of the thirty-year average is entirely natural; Egyptians of the seventh and eight centuries would have been incorrect to assume that the worsening drought during that time was the “new normal.”

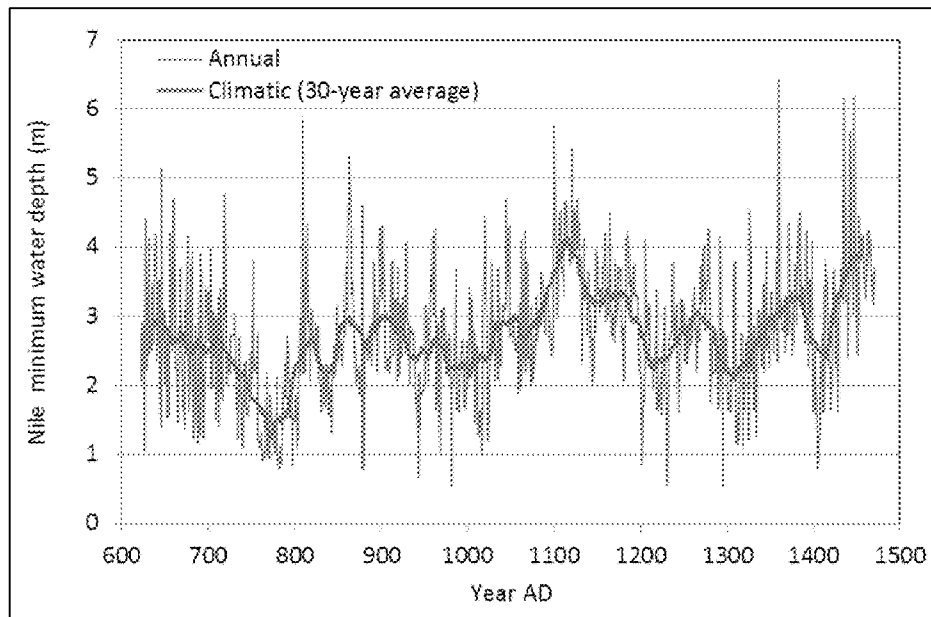


Figure 6.1.1: The annual minimum depth of the Nile River near Cairo over more than 650 years from 622 to 1284 A.D. The data, measured in meters, shows a characteristic pattern of year-to-year fluctuations around longer-term trends. Data from (Koutsoyiannis 2013)

With these caveats in mind, we examine the evidence for changes in selected weather and climate extremes. An emergent theme is the wide gap between public perceptions and scientific evidence. It has become routine in media coverage, government and private sector discussions, and even in some academic literature to make generalized assertions that extreme weather of all types is getting worse due to GHGs and “climate change.” Yet expert assessments typically have not drawn such sweeping conclusions and instead have emphasized the difficulty both of identifying specific trends and establishing a causal connection with anthropogenic forcing.

In the sections to follow we provide excerpts from various IPCC and NCA assessment reports denoting the sources as follows:

SREX: The IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (2012)

AR6: The IPCC Sixth Assessment Report Working Group 1 (2021).

NCA4: The US Climate Science Special Report of the Fourth National Climate Assessment (2017) Volume I.

NCA5: The US Climate Science Special Report of the Fifth National Climate Assessment (2023) Volume I.

Note that in the excerpts, *italics* are in the original whereas **boldface** emphasis has been added.

Additionally we present updated data series from standard government sources to provide up-to-date information through 2024 wherever possible.

6.2 Hurricanes and Tropical Cyclones

The AR6 provides the following assessment of tropical cyclones (TCs; used here as a synonym for hurricanes):

AR6: There is *low confidence* in most reported long-term (multidecadal to centennial) trends in TC frequency or intensity-based metrics due to changes in the technology used to collect the best-track data. (IPCC, 2021)

AR6: It is *likely* that the global proportion of major (Category 3–5) tropical cyclone occurrence has increased over the last four decades . . . There is *low confidence* in long-term (multi-decadal to centennial) trends in the frequency of all-category tropical cyclones. (IPCC, 2023)

AR6: A subset of the best-track data corresponding to hurricanes that have directly impacted the United States since 1900 is considered to be reliable, and shows **no trend in the frequency of U.S. landfall events**. (IPCC, 2021)

Since 1980, when satellite observations fully covered the global oceans, we have confidence in the numbers of total global hurricanes and major hurricanes (Category 3 and higher). Figure 6.2.1 shows that on average, each year there are about 50 hurricanes, with about 25 reaching major hurricane status (Maue, 2025). There is substantial year-to-year and decadal variability a weak decreasing trend in the number of hurricanes and a slight but insignificant increasing trend in the number of major hurricanes These two trends combine to create an increasing trend in proportion of major hurricanes.

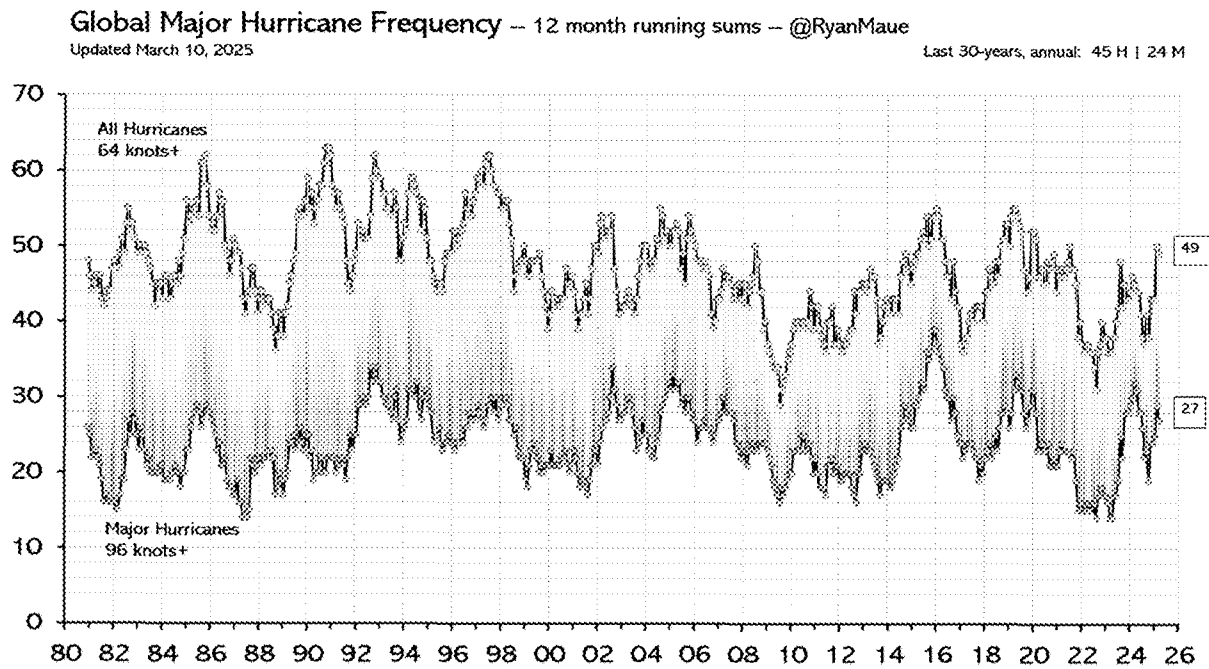


Figure 6.2.1: Global frequency of hurricanes and major hurricanes since 1980.

Global hurricane statistics are dominated by the Northwest Pacific Ocean, which accounts for ~35 percent of total global hurricanes, whereas the Atlantic accounts for ~15 percent of global hurricanes (CSU, 2025). Data in the Atlantic basin extends further back than in the other ocean basins, and is most relevant to U.S. policy makers.

Figure 6.2.2 shows the frequency of Atlantic hurricanes and major hurricanes (Category 3 and higher) back to 1920. Data prior to 1965 (the onset of satellite observations in the Atlantic, shaded in blue) shows some undercounting, with data prior to 1920 showing substantial undercounting (Vecchi and Knutson, 2011). All measures of Atlantic hurricane activity show a significant increase since 1970. However, the period from 1971-1994 was a period of exceptionally low activity, with high values of hurricane activity (comparable to the past two decades, even with undercounting) also observed during the 1950's and 1960's, and even in the 1930's.

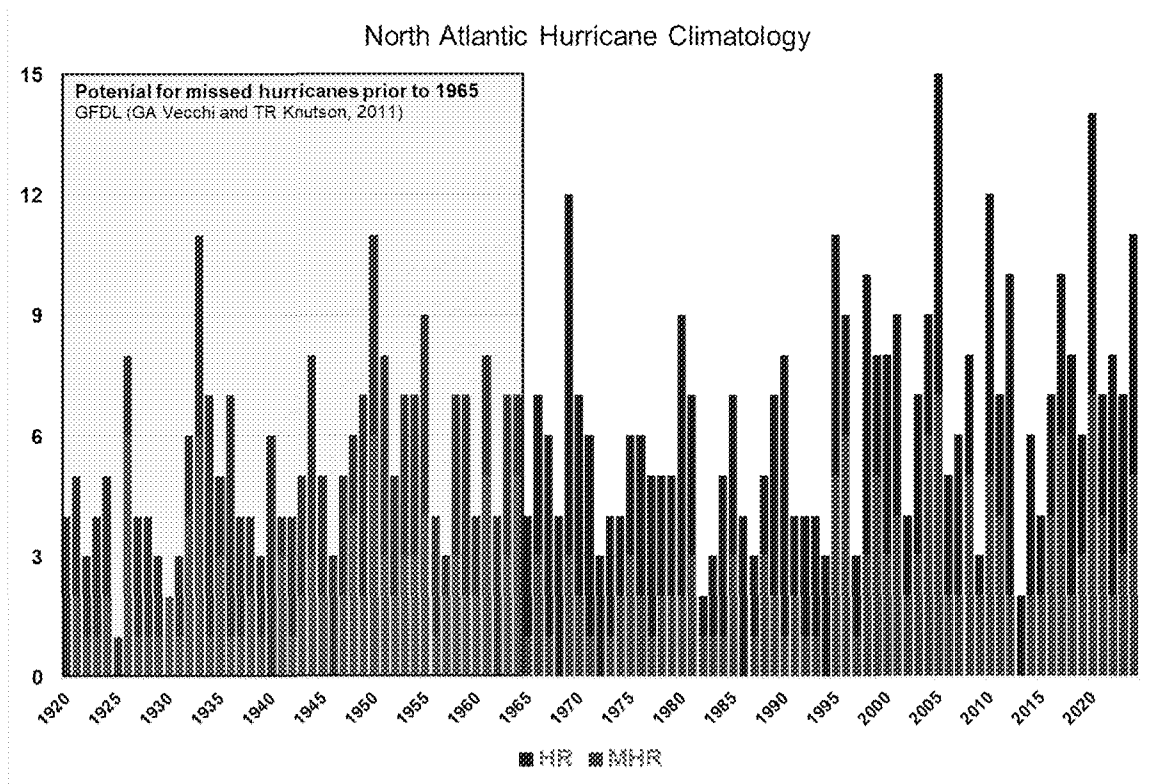


Figure 6.2.2: Atlantic frequency of hurricanes (HR) and major hurricanes (MHR) since 1920. Source (NHC, 2024)

Figure 6.2.2 shows that Atlantic hurricanes vary strongly on decadal and multidecadal time scales. These variations are associated primarily with the Atlantic Multidecadal Oscillation (AMO), which is manifest in basin-wide sea surface temperature and sea level pressure fluctuations connected to large scale ocean circulation patterns. The AMO was in its warm phase during 1926-1970 and 1995-present, but in its cool phase during 1971-1994. The AMO has its greatest impact on the number of major hurricanes (Category 3+), identified by Goldenberg et al. (2001) to be associated with above normal SSTs and decreased vertical shear in the AMO warm phase (see also Bell and Chelliah, 2006; Klotzbach et al., 2018).

Klotzbach et al. (2018) conducted a comprehensive evaluation of the landfalling hurricane data for the Continental U.S. since 1900. Figure 6.3.3 updates their analysis through 2024. While the largest numbers of hurricanes are from 2004, 2005 and 2020, there is no statistically significant trend since 1920. Figure 6.2.3 also shows the time series for major hurricane landfalls (Category 3-5). The largest year in the record is 2005, with 4 major hurricane landfalls. However, there were no major hurricanes striking the U.S from 2006 through 2016, the longest such period since 1920.

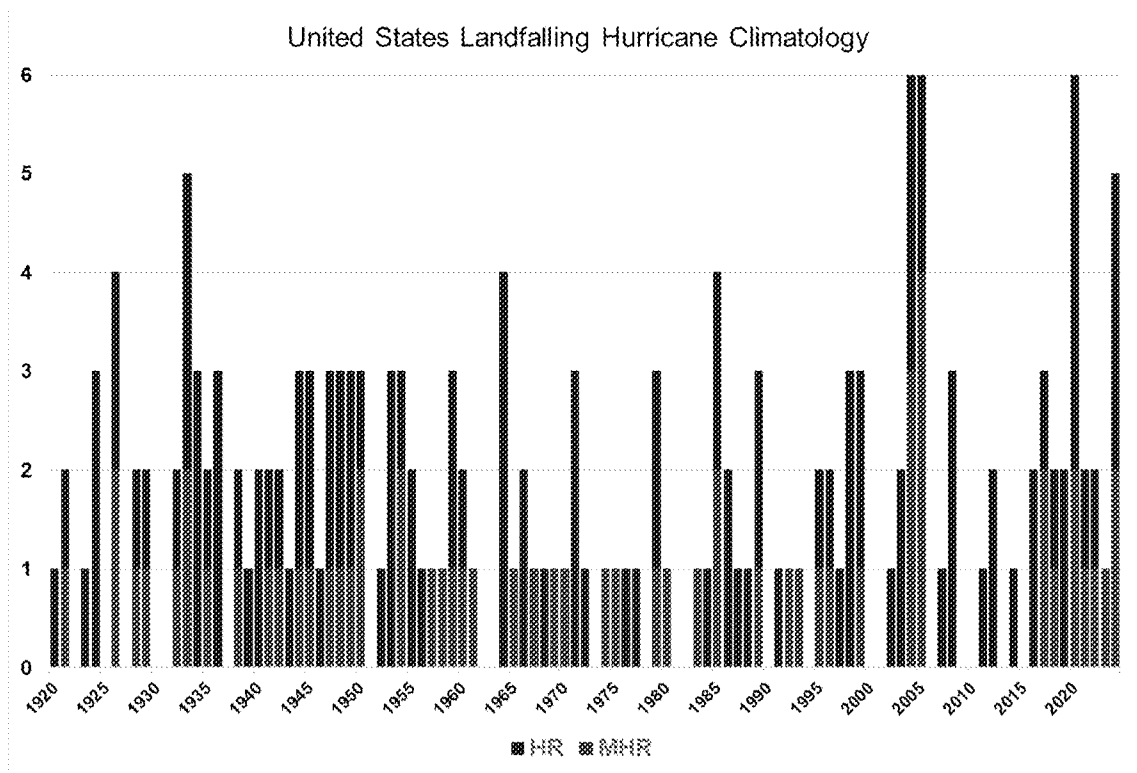


Figure 6.2.3: US landfalling frequency of hurricanes (HR) and major hurricanes (MHR) since 1920.
Source (NOAA HRD(a), 2024)

Substantial interannual to multidecadal variability in U.S. landfall activity is seen Figure 6.2.3. Klotzbach et al. (2018) examined how the landfall counts vary with ENSO (El Niño versus La Niña) and the warm versus cold phases of the Atlantic Multidecadal Oscillation (AMO).

Villarini et al. (2012) provide an analysis of U.S. hurricane landfalls back to 1878. While it is possible that some landfalls were missed in the late 19th century owing to sparsely populated regions on the Gulf Coast, it is remarkable that the highest year in the entire record, is 1886, with 7 landfalls,

Table 6.2.1 shows the 10 strongest hurricanes (plus ties) to make U.S. landfall. Of the hurricanes that have made landfall with sustained winds greater than 150 mph, only one has occurred in the 21st century.

In summary, analyses of both global and regional variability and trends of hurricane activity provide the basis for detecting changes and understanding their causes. The relatively short historical record of hurricane activity, and the even shorter record from the satellite era, is not sufficient to assess whether recent hurricane activity is unusual relative to the background natural variability. Atlantic hurricane processes are influenced substantially by the natural modes of ocean circulation variability in the Atlantic, notably the Atlantic Multidecadal Oscillation. While it has long been hypothesized that a rising global sea surface temperature would cause an increase in hurricane intensity, identification of any significant trend in the hurricane data is hampered by a short data record and substantial natural variability.

Table 6.2.1 Strongest hurricanes to make landfall along the US coast. Source (NOAA HRD(b), 2024)

Rank	Year	Landfall	Name
		Wind (MPH)	
1	1935	185	"Labor Day"
2	1969	175	Camille
3	1992	165	Andrew
4	2018	160	Michael
5	1856	150	"Last Island"
5	1886	150	"Indianola"
5	1919	150	-----
5	1932	150	"Freeport"
5	2004	150	Charley
5	2020	150	Laura
5	2021	150	Ida
5	2022	150	Ian

6.3 Temperature extremes

The AR6 assessment focused on the period after 1950 and reported increasing trends in heatwave frequency and intensity. However, the NCA4 noted that heatwave activity in the US reached a peak in the 1930s.

AR6: “It is *virtually certain* that hot extremes (including heatwaves) have become **more frequent** and **more intense** across most land regions since the 1950s, while cold extremes (including cold waves) have become less frequent and less severe” (SPM, A3.1)

AR6: “In North America, there is very robust evidence for a *very likely* increase in the intensity and frequency of hot extremes and decrease in the intensity and frequency of cold extremes for the whole continent, though there are substantial spatial and seasonal variations in the trends. Minimum temperatures display warming consistently across the continent, while there are more contrasting trends in the annual maximum daily temperatures in parts of the USA.” (Chapter 11, p 1550)

NCA4: “Changes in warm extremes are more nuanced than changes in cold extremes. For instance, the warmest daily temperature of the year **increased** in some parts of the West over the past century, but there were **decreases** in almost all locations east of the Rocky Mountains. In fact, all eastern regions experienced a net **decrease**, most notably the Midwest (about 2.2°F [1.2°C]) and the Southeast (roughly 1.5°F [0.8°C]).” (pp. 190-191)

NCA4: “Since the mid-1960s, there has been only a very slight increase in the warmest daily temperature of the year (amidst large interannual variability). Heat waves (6-day periods with a maximum temperature above the 90th percentile for 1961–1990) increased in frequency until the mid-1930s, became considerably less common through the mid-1960s, and increased in frequency again thereafter. As with warm daily temperatures, **heat wave magnitude reached a maximum in the 1930s.**” (pp. 190-191)

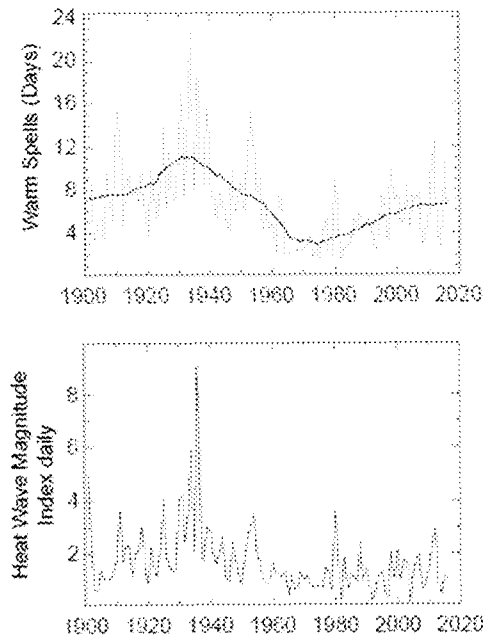


Figure 6.3.1: US Heat waves since 1900. Source: NCA4 Figure 6.4

6.3.1 Temperatures in the US are becoming less extreme

Daily maximum temperatures in the warm season (Tmax, May-Sep) and daily minimum temperatures in the cold season (Tmin, Dec-Mar) are available beginning in Dec 1898 (126 years). The dataset consists of 1,211 CONUS stations designated as United States Historical Climate Network or USHCN stations (see Figure 6.4.2; Quinlan et al. 1987, Karl et al. 1990). These stations were selected by NOAA as having the fewest problematic issues with gaps, station moves and instrument changes. Where gaps still exist, nearby stations (bias-corrected) were merged so that the median volume of data available for a station is 98%. Although there are certainly errors in the dataset, with over 1,000 stations we can have relatively high confidence in any underlying signal that might be discovered.

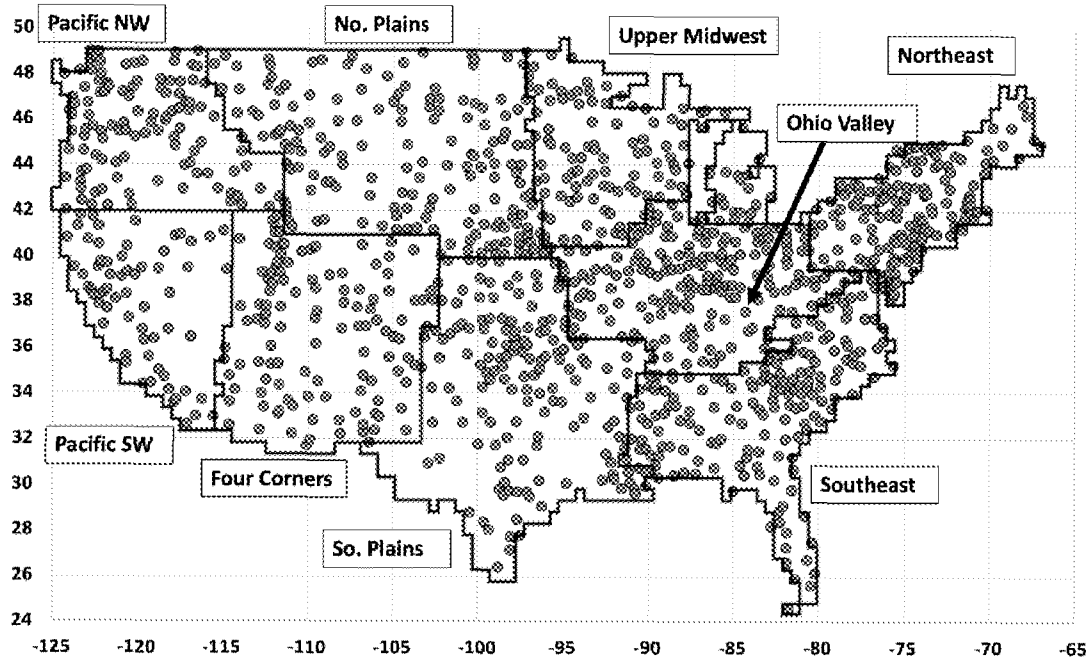


Figure 6.3.2 Locations of USHCN temperature stations. Source: USHCN.

We begin with the question of whether the occurrence of daily record high or low temperatures has changed since Dec 1898. Each warm-season has 153 days (1 May to 30 Sep) and each cold-season has 122 days (1 Dec to 31 Mar). For each station and day, we calculated the year in which the record highest (lowest) temperature occurred. With 126 years of observations, if there were no temperature trends over time, the expected number of records for Tmax would be 1.21 ($=153/126$) per station per year and for Tmin 0.96 ($=122/126$) per station per year.

Figure 6.3.3 shows the observed distribution in time of the occurrence of these extreme events. There is a common feature in many metrics of warm-season extremes in the CONUS - the exceptional heat of the 1920s and especially the 1930s, peaking in 1936. On a per-station average, 60% of the Tmax records and 59% of the Tmin records occurred in the first half of the period (1899-1961).

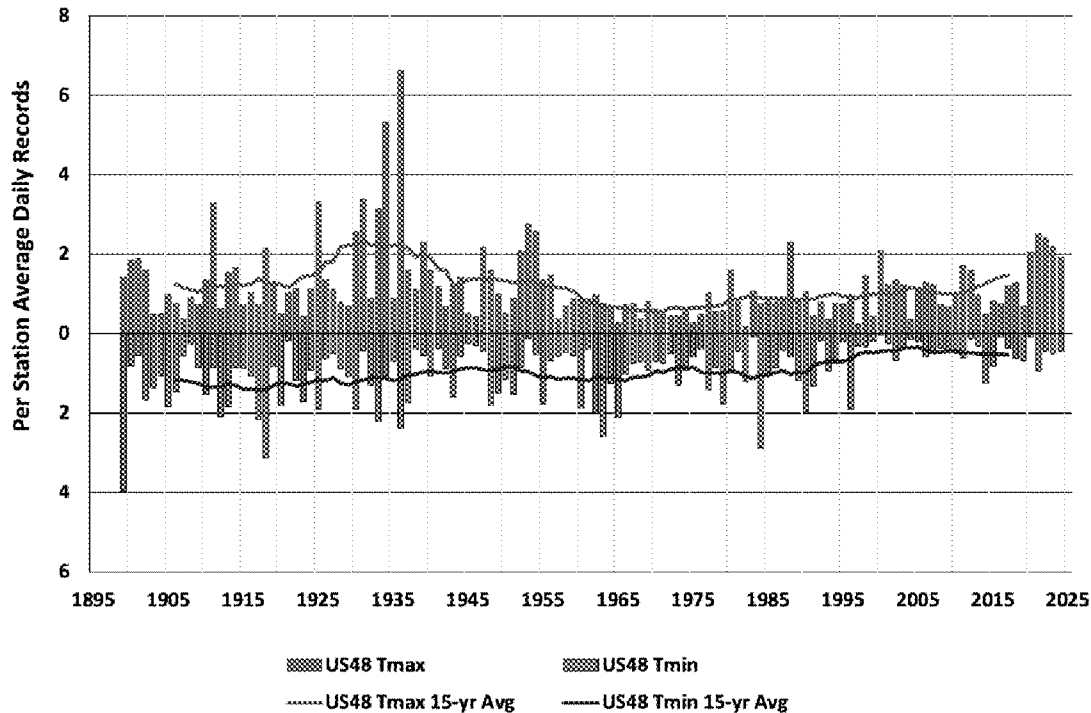


Figure 6.3.3 Number of daily record High (red) and Low (blue) temperatures for warm and cold seasons in the CONUS. The lines represent the 15-year running, centered average. Source: 1,211 USHCN stations supplemented as needed to achieve a minimum of 92% of observations in the 126-year period since Dec 1898. US48: contiguous US states. Tmax: maximum temperature. Tmin: minimum temperature.

On the cold side, the Valentine’s Day Arctic outbreak in Feb 1899 stands as the most extensive cold extreme experienced by the CONUS, with 1917 in 2nd place. The frequency of cold records has declined, especially over the last quarter of the period in which only 13% of the extreme cold events were measured. In contrast, 25% of the extreme Tmax records were achieved in the last quarter, in accordance with statistical expectations. These general features have been noted in past assessments (see above, IPCC AR6, NCA4). Combining the two records the overall reduction in numbers of both cold and hot extremes over the past century indicates a climate less prone to extremes.

This pattern is also shown in Figure 6.3.4. For each station and for each year the hottest warm season and coldest cold-season temperatures were calculated. Then the differences between these were computed by station and geographically-averaged over all stations, thus yielding an annual measure of the expected range of local extreme temperatures for each year. Figure 6.3.4 shows the 15-year trailing average of this measure, which has clearly declined over the past century.

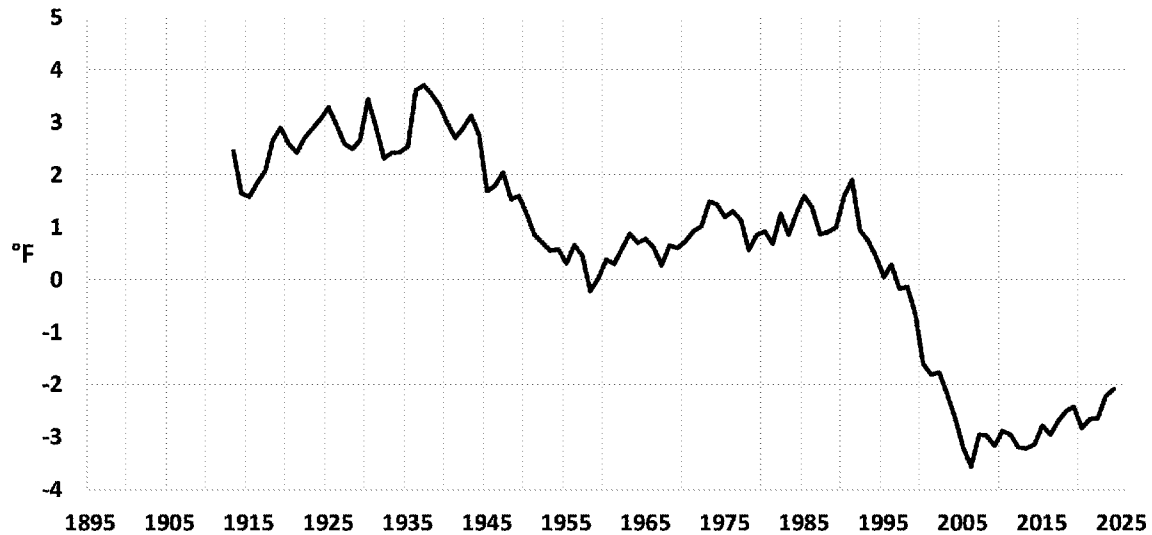


Figure 6.4.4. 15-year trailing average of the difference each year of each station’s hottest warm-season Tmax and coldest cold-season Tmin relative to the long-term average. Source: USHCN, author calculations.

The average difference for each station between the hottest summer Tmax and coldest winter Tmin has declined by about 5°F in the past 126 years. The decline is due mostly to warmer winter Tmin, but a decline in summer Tmax is also a factor. The rise in Tmin has been strongly related to the growing presence of manufactured surfaces around the weather stations over the last 100+ years (the so-called urban heat island effect; Spencer et al. 2025).

In summary, while temperature extremes are regularly experienced in the U.S. and attract a great deal of media attention, long term records show the US climate has become less extreme over time (milder) when measured by the range between warm season maxima and cold season minima.

6.3.2 Exceedances of a heat threshold

Under the heading of “The Risk of Temperature Extremes is Changing”, the most recent US National Climate Assessment report (NCA5) notes the increase in a threshold metric of number of days at or above 95°F, stating,

“The western US has been particularly affected by extreme heat since the 1980s ..., experiencing a larger increase in days over 95°F, as would be expected given the greater warming in that region relative to the eastern US. Several major heatwaves have affected the US since 2018, including a record-shattering event in the Pacific Northwest in 2021.”

Are the occurrences of 95°F days changing? In a climate as varied as that of CONUS, threshold statistics can be misleading. A region with many stations that have near 95°F Tmax average temperatures in the summer might see large swings in the metric when only small changes in average temperature occur. Elsewhere with stations that either rarely or virtually always achieve 95°F Tmax temperatures, a small change will not have much impact on the results. In the past 126 years, the average CONUS station

experienced 129 days exceeding 95°C per 6-yr period, but the regional values range from 278 in the Southern Plains to 9 in the Northeast. Thus, such threshold analyses must be interpreted with caution.

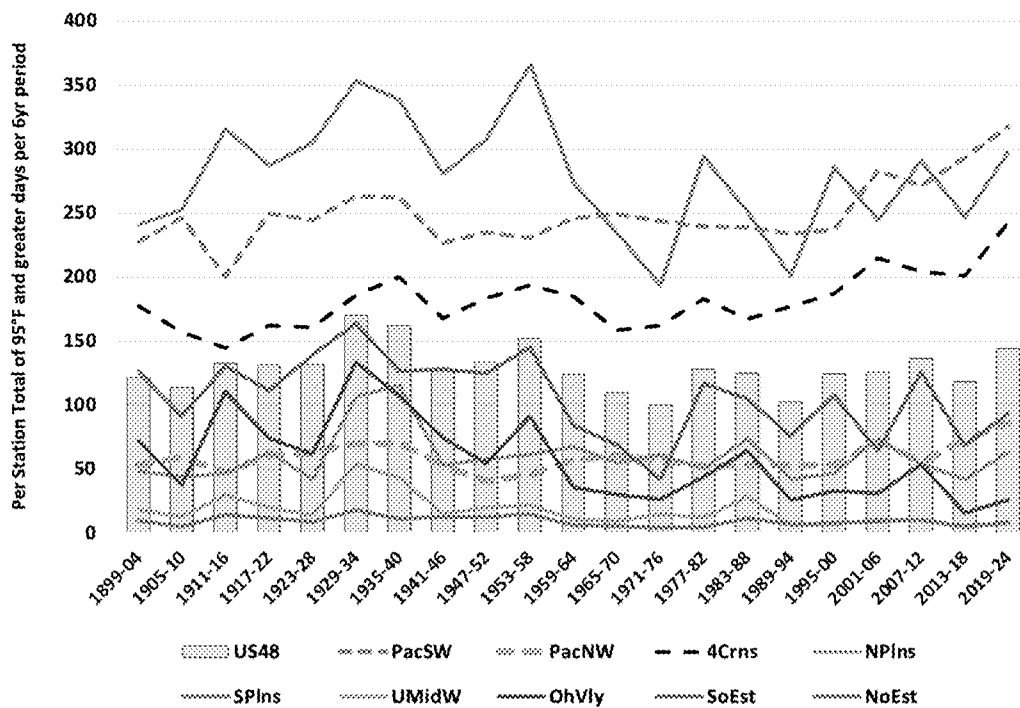


Figure 6.3.5. Total number of days $\geq 95^{\circ}\text{F}$ in 6-yr periods, US 48 (bars) and regions (lines). Interval is 6-years as this is divisible into 126. Source: USHCN, author calculations. US48: contiguous US states. See Figure 6.3.2 for region names.

Figure 6.3.5 shows that only three of the nine regions, all in the West, have experienced upward trends in the number of 95°F or hotter days (dashed lines). The CONUS as a whole has not, and the other six regions have experienced declines.

The Pacific NW heatwave of 2021 referenced in the NCA5 quote will be examined more closely in Section 8.5. The evidence indicates that it was a single, unprecedented event in the record, not part of a pattern of increasing extreme heat. For example, the 5-day average tropospheric grid-point temperature anomaly over the Pacific NW during that event was +10.8 C, the most extreme Northern Hemisphere grid point summer anomaly in the 46 years from over 4 million grid values. In contrast, the global temperature anomaly during that time was virtually zero (+0.03 C, Mass et al. 2024).

The NCA5 heading “The Risk of Temperature Extremes is Changing” suggests pervasive positive trends are now being observed in threshold temperatures, but that is not evident in the figures above.

6.3.3 Heatwaves

Heatwaves (consecutive days that exceed an extreme threshold) have a greater societal impact than a single daily record temperature. We measure “Heatwave Days” here as the count of all days in May-Sep each year that exceed the 90th percentile for that day and that lie within a period of at least six consecutive days. This is equivalent to the method used in NCA4, except that the reference period here is the entire record 1899-2024 while NCA4 truncated the reference period to 1961-1990, which was a cool period. That truncation boosts positive results (days exceeding the 90th percentile) in periods warmer than the reference period, especially starting in 1960 and moving to the present (see *Urban Influences* below).

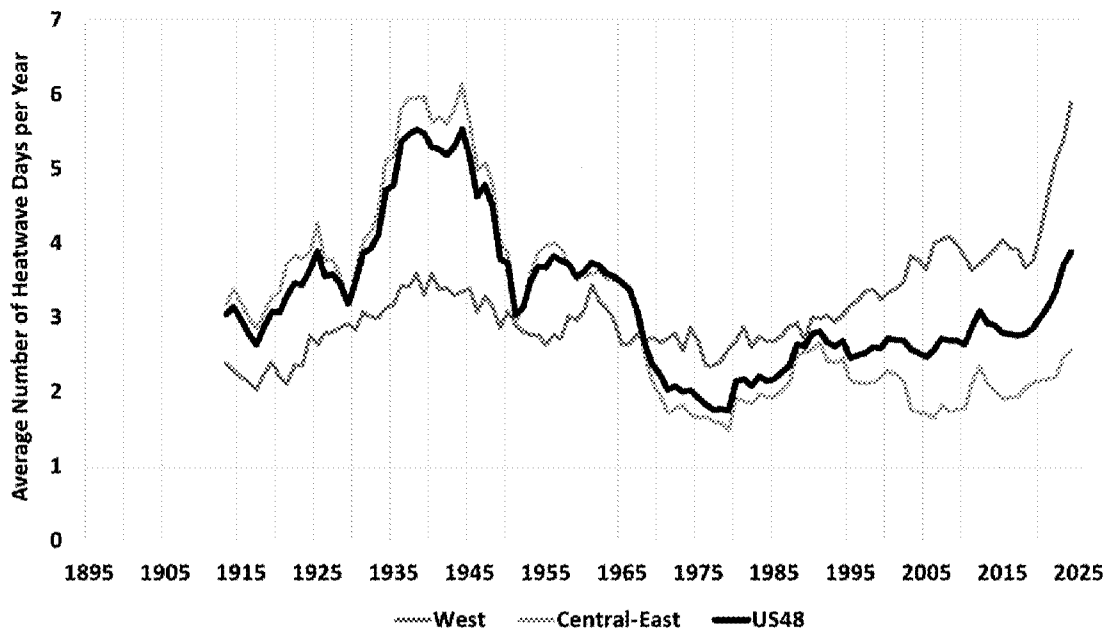


Figure 6.3.6 15-year trailing average of number of heatwave days per year per station in the CONUS (black line) and four regions: West (red), Central-east (green).

Figure 6.3.6 indicates that there are regional variations in heatwave activity. The excessive heat of the first half of the 20th century occurred primarily in the eastern two-thirds of the nation, while the West has seen a recent increase of heatwave days (NCA5). This indicates that the background warm season circulation favored heatwaves in the eastern portions of the country in the first half of the 20th century, but in the 21st century the patterns have favored heatwaves in the West. For CONUS as a whole, heatwaves are no more common today than they were a century ago, consistent with the upper panel of our Figure 6.4.1 taken from NCA4.

This metric varies significantly with region. The four northern regions (Pacific NW, Northern Plains, Upper Midwest, and Northeast) on average experience 15 to 27 heatwave days per 15-year period. In contrast, the five southern regions (Pacific Southwest, 4-Corners, Southern Plains, Ohio Valley and Southeast) see 37 to 54 such days, essentially twice as many. This suggests the summer circulation pattern is more prone to stationary events in the southern regions while transient systems in the northern regions are more common and thus cut short these potentially longer events.

The analysis of heatwaves is an example of why it is important to consider complete datasets and appropriate metrics. The NCA5 directs readers to the website

<https://www.globalchange.gov/indicators/heat-waves> (USGCRP 2023) to view a figure showing the number of urban heatwaves by decade from the 1960s, which we reproduce as Figure 6.3.7.

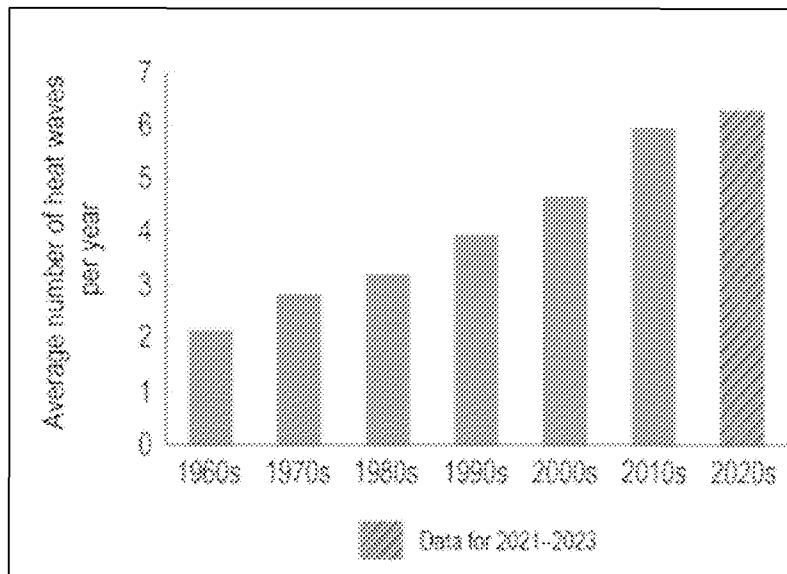


Figure 6.3.7: Average number of urban heatwaves per year for 50 large U.S. metropolitan areas. From <https://www.globalchange.gov/indicators/heat-waves>

The figure shows a monotonic increase in each decade from 2 occurrences per year in the 1960s to 6 in the 2020s. The definition of a heatwave used is an unusual but practical measure of human discomfort - a period of at least 2 consecutive days when the *minimum* apparent temperature (combination of temperature and humidity) exceeds the 85th percentile. Note too, the dataset is limited to the 50 largest U.S. cities.

Given the unusual heatwave definition and urban focus, these increasing values since 1960 presented in USGCRP (2023) are not informative about long term trends or the influence of GHG emissions for at least two reasons. First, as shown in Figures 6.3.1 and 6.3.6, the 1960s was the coldest decade and 1970s the second coldest decade since the 1910's, so this starting date preconditions the time series to show increases. Second, post-1960 urbanization in these cities is a major factor in the rise of Tmin relative to co-located Tmax and relative to Tmin at nearby rural stations. This does not dismiss the real rise in nighttime temperatures in major U. S. cities and the societal impacts associated with these changes. However, we note for a variety of reasons, that summer Tmax (especially in rural areas) is a better metric for detecting changes in heatwaves influenced by changes in the background climate due, for example, to increasing GHGs (Christy et al. 2009). For the CONUS as a whole, the evidence in this section suggests GHG emissions have had little-to-no effect on heatwaves.

6.4 Extreme precipitation

The IPCC AR6 assessed that an increase in heavy precipitation has been observed in data starting in the 1950s.

AR6: “The frequency and intensity of **heavy precipitation events have increased** since the 1950s over most land area for which observational data are sufficient for trend analysis (high confidence).” (SPM A3.2)

AR6: “In North America, there is robust evidence that the **magnitude and intensity of extreme precipitation has *very likely* increased** since the 1950s. Both [one-day maxima] and [5-day maxima] have significantly increased in North America during 1950-2018 “(Chapter 11, p. 1560)

The US National Climate Assessments (NCA4, NCA5) have highlighted an increase in the occurrence of the heaviest precipitation events (defined in different ways) primarily in the eastern half of the CONUS, especially the Northeast, when starting the analysis in either 1901 or 1958. Interestingly, the regional variations indicate that the largest increases in extreme precipitation events are in the Northeast and the smallest in the West, a pattern counter to the changes in temperature extremes.

McKittrick and Christy (2019) examined long-term and consistent station observations of extreme daily precipitation to test some of these NCA claims for the Southeast and West Coast using a trend model with a non-parametric variance estimator robust to the complex autocorrelation properties of precipitation data. When the time series were extended back in time (as far as 1872 in some cases) or when starting later (1978), there were no significant trends for either region.

These findings have been updated for this report with similarly constructed observations from 29 stations on the CONUS Pacific Coast (1893ff from San Diego CA to Blaine WA) and 24 stations in the humid Southeast (1872ff from Austin TX to Washington DC), also adding 27 stations in the Northeast (1888ff from Buffalo NY to Eastport ME). The locations are shown in Figure 6.4.2. The stations were selected on the basis of availability of long-term high-quality records. The regions are each associated with important features of extreme precipitation behavior. The Pacific coast is associated with landfalling atmospheric rivers. The NCA report has indicated that the Northeast has experienced the greatest increase in extreme events. The Southeast is also a place noted in the NCAs for increased extreme events.

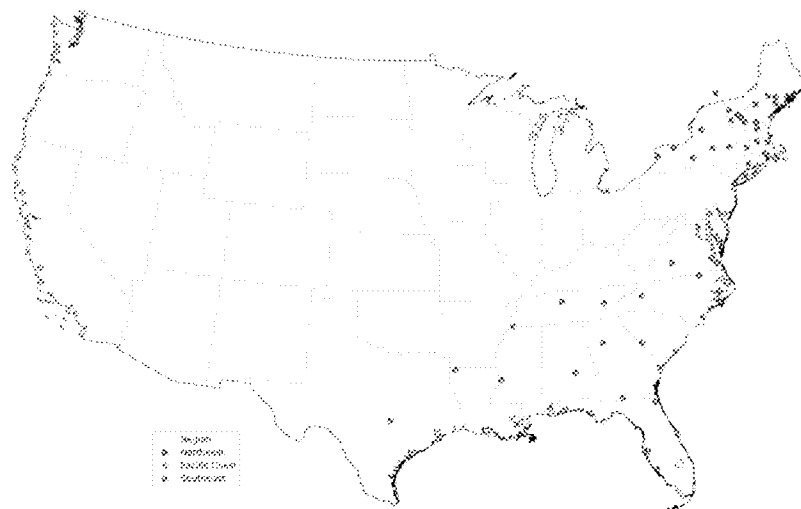


Figure 6.4.2: Locations of precipitation monitoring stations used in this report. Orange: Pacific coast. Blue: Northeast. Green: Southeast.

The results of applying the analysis of McKittrick and Christy (2019) were as follows for each region, then followed by further explanation.

Pacific Coast heavy rainfall events

- Average precipitation trend is statistically significant (downwards) in Astoria OR; insignificant elsewhere.
- The trend in rainfall variance is positive and significant in Big Sur CA; insignificant elsewhere.
- The trend in daily maximum precipitation is positive and significant in Aberdeen WA and Big Sur CA and negative and significant in Newport OR (insignificant elsewhere).
- Averaged over all stations in the region, none of these three trend parameters is statistically significant.

The Pacific Coast receives considerable precipitation from Atmospheric River (AR) events which often last more than a day or two (e.g., Gershunov et al. 2017, Pan et al. 2024). The worst series of such events in recent history was the so-called ARkStorm that occurred between December 1861 and January 1862; it dumped nearly 10 feet of rain in parts of California and submerged the entire Central Valley for weeks under as much as 15 feet of water (Brewer 1930, Null and Hulbert 2007). Additionally, Paleoclimate research has found six megastorms more severe than 1861–1862 in California during the last 1800 years, occurring at intervals of 300 years or so (Porter et al. 2011).

BOX: Perils of short data records

San Francisco provides a good case study of the limitation of using short historical samples to characterize natural variability of extreme events. Suppose we use a 130-year sample of daily San Francisco precipitation from 1895 to 2024 and we look for 3-day, 5-day, 14-day and 30-day rainfall records. The results are as shown in Table 7.2.

Event	Record (inches)	Year
3-day	6.94	2023
5-day	8.55	2023
14-day	12.62	2023
30-day	18.93	1998

Table 6.2: Extreme rainfall records, San Francisco, 1895-2024.

The records all cluster in the more recent years. 2023 appears to be an exceptional year and since it is near the end of the sample, it might suggest that the climate has shifted into a more hazardous state, perhaps as a result of human influences. [Note: “2023” indicates the event occurred in the water-year of Aug 2022 to Jul 2023.]

But the picture is very different if we use a sample that begins 45 years earlier, in 1850. Table 6.3 shows that the record-setting events all happened in the 1860s. Furthermore 2023 is now not even in 2nd place but falls to 3rd or 4th place. Also, comparing the records of the

two charts the extreme precipitation events in 1862 and 1867 involved considerably more rainfall than the 1998 and 2023 events, with 14- and 30-day totals about 50 percent higher.

Event	Record (inches)	Year	Rank of 130-yr extreme
3-day	8.85	1867	3
5-day	9.80	1867	3
14-day	19.05	1862	4
30-day	28.25	1862	2

Table 6.3: Extreme rainfall records, San Francisco, 1850-2024.

The range of natural variability is made even more remarkable when paleoclimate evidence is examined. Porter et al. (2011) discovered that in the past 1,800 years at least six megastorms were more intense than the devastating 1861-62 ArkStorm that struck the region. Evidently such extreme events, “unprecedented” in our 1895-2024 sample, have impacted the region about every 300 years, though not since 1895.

This example illustrates the limitations of using relatively short climate periods (~130 years) to assess the character and range of natural variability in general and of extreme events in particular. Accurate representation of the full range of natural variability is necessary for any attribution analyses (see 6.4). Infrastructure planners, emergency management institutions and attribution scientists would understand the significant mischaracterization of the magnitude of a future extreme if based only on the last 130 years. In this case, a single time-sample of 130 years provides an underestimation of the extreme value by up to 50% determined when adding only 45 more years of observations. Compared to millennial-scale paleoclimate evidence, an even greater underestimation would occur. An important lesson is that the climate can deliver great surprises on its own, even without human influences.

We examine occurrences of 5-day deluges as follows. Taking the Pacific coast as an example, a 130-year span contains 26 5-year intervals. At each location we computed the 5-day precipitation totals throughout the year and selected the 26 highest values across the sample. A single year may have more than one of the 26 heaviest. Each of those can be thought of as 1-in-5yr events. If there are no trends in precipitation, then the total number of these events across all stations should be evenly spread out over the years. In Fig. 6.5.3 we show the distribution in time of these events for the Pacific coast. The deluges associated with the massive 1997-98 El Niño event are readily apparent. While erratic, as is typical of such precipitation metrics, there is no indication of a tendency to become more frequent over time.

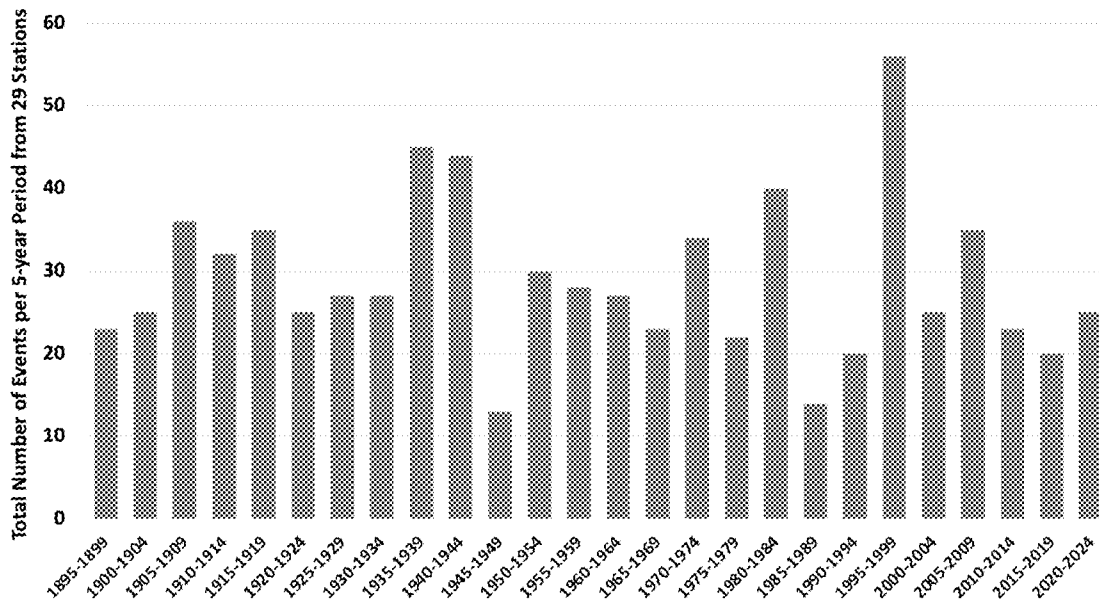


Figure 6.5.3. The time distribution by 5-year periods of the 26 heaviest (1-in-5 yr) occurrences for 29 stations on the Pacific coast.

Southeast heavy rainfall events

- The trend in average precipitation is positive and statistically significant in Mobile AL and Quitman GA, and insignificant elsewhere.
- The trend in rainfall variance is positive and significant in Mobile AL, insignificant elsewhere.
- The trend in daily maximum precipitation is positive and significant in Vicksburg MS and Norfolk VA, and insignificant elsewhere.
- Averaged over all stations in the region none of these three trend parameters is statistically significant

Figure 6.5.4 shows the same calculation for the last 150 years in the Southeast humid zone. The temporal pattern of 5-day totals of the 1-in-5yr heavy events is generally unremarkable, though a cluster of higher values appears in 1995 to 2019. The increase in those years is due largely to the 4 northeastern-most stations of Wilmington NC, Weldon NC, Washington DC, and Norfolk VA. This confirms the pattern indicated in NCA4 and NCA5 -- an increasing frequency of heavy events due to a temporal clustering of tropical storms from eastern NC to Maine discussed below. Otherwise, the remaining 20 stations show an unremarkable temporal distribution of heavy events.

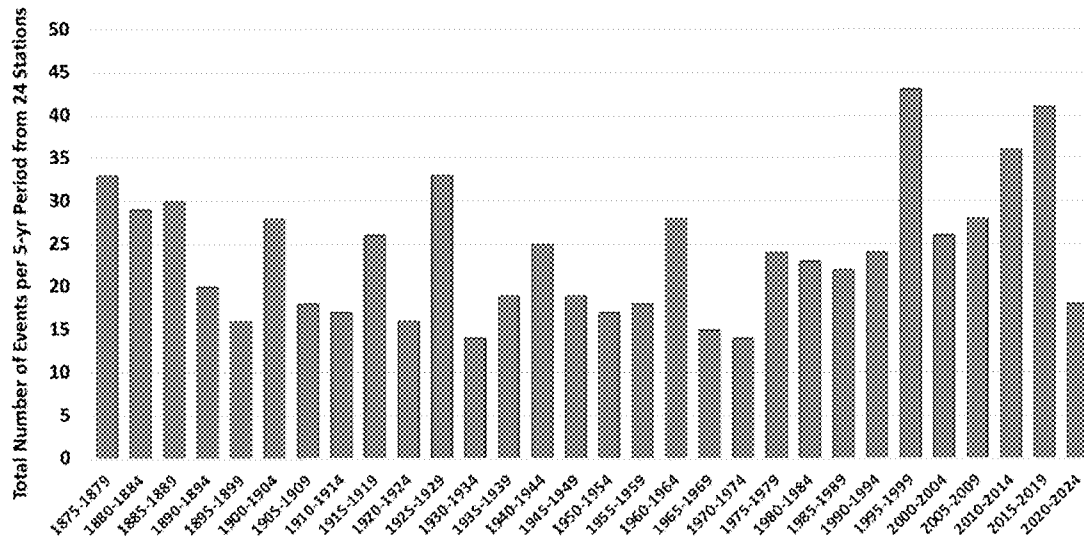


Figure 6.5.4. As in Fig. 6.5.3 but for the heaviest 30 (1-in-5yr) events for 24 stations in the humid Southeast from Austin TX to Washington DC in 5-year bins for 1875-2024.

Northeast heavy rainfall events

- The trend in average precipitation is positive and statistically significant in 12 of 27 locations and also in the regional average.
- The trend in rainfall variance is positive and significant in Portland ME, Albany NY, Buffalo NY and Eastport ME, but insignificant elsewhere.
- The trend in daily maximum precipitation is positive and significant in Portland ME, Gardiner ME and Eastport ME, but insignificant elsewhere.
- When averaged over all stations in the region, there is no statistically significant trend in either the precipitation variance or maximum

Fig. 6.5.5 shows the same calculation for the last 135 years in 21 stations in the Northeast (including Montreal Canada). We use 3-day totals here as this produced the largest temporal variations in time. In this region, 72% of events occur during June to October and are dominated by incursions of hurricanes, tropical storms, or tropical storms that transition to extratropical systems. According to NCA4 and NCA5 this region experienced the largest increases in extreme events, so it merits a closer examination.

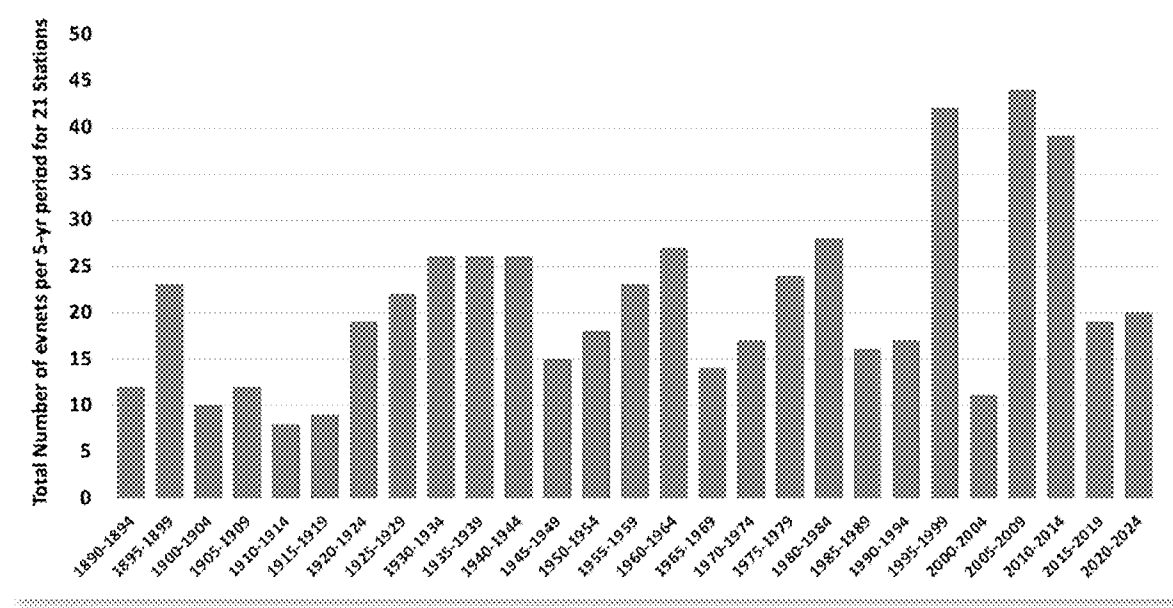


Figure 6.5.5. As in Fig. 6.5.3 but for the heaviest 27 (1-in-5yr) 3-day precipitation events for 27 Northeast stations from NY to ME, including Montreal.

There is a noticeable clustering of extreme events from 1995 to 2014. Howarth et al. (2019) examined a similar region as in Fig. 6.5.5 that includes PA and NJ and reported significant differences between two 18-year periods, 1979-96 and 1997-2014, of various precipitation extremes, including a 317% increase in 24-hr events exceeding 6 inches, while we find a 51% increase over the same years. However, Figure 6.5.5 shows that frequency drops sharply after 2014, returning to the long-term average in the subsequent 5 year intervals, again illustrating the perils of drawing conclusions from short-term trends in highly variable metrics.

Also the high percentage increase in the Howarth et al. sample is associated with small numbers at relatively few locations: there were only 6 in the first period and 25 in the second across 58 stations. Most of the stations did not record such an event. If there is a region-wide increase in heavy events, it should be seen in the average across all stations. Figure 6.5.6 shows the average precipitation in the 1-in-5 yr events across the NE. The trend is only +0.02"/decade. The highest amount, 1935-39, includes the Great New England Hurricane of 1938, one of the rare major (Category 3 or higher) hurricanes to strike the region. The results in Figs. 6.5.5 and 6.5.6 thus suggest that though there was a surge in the number of events at a few locations during the 1995 to 2014 interval, there was no regional pattern and the change did not persist beyond 2014.

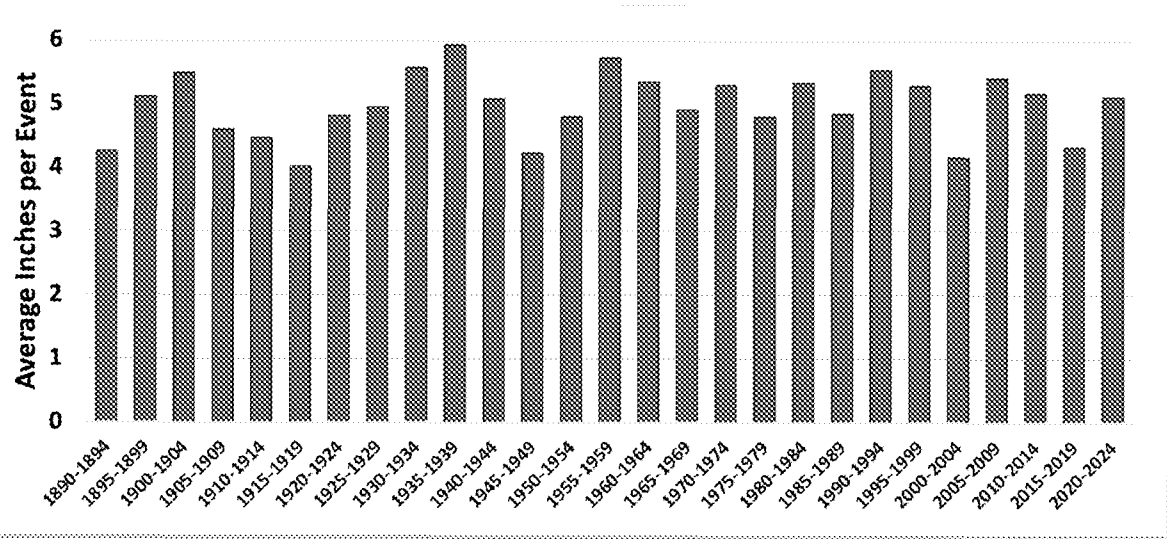


Figure 6.5.6. Average amount of precipitation falling in the 1-in-5yr events for the NE stations.

Jong et al. (2024) document the increase of tropical influences on precipitation events in the Northeast since 1959 and concluded, “The autumn extreme precipitation trend over the Northeast US is primarily attributed to tropical cyclone-related events since the 1990s.” The question then becomes: was the temporal clustering of tropical systems in 1997-2014 which affected the Northeast a response to increasing GHGs? Jong et al. examined CMIP-6 model output which suggests that there will be fewer such systems in the 21st century but that the intensity of the rainfall events might increase. This conjecture is not seen in Fig. 6.5.6 where the amount-per-event has remained steady over the 135-year period.

There is some evidence to indicate the heaviest rainfall events may be redistributed due to the impact urban infrastructure has on the local weather (e.g., Pielke Sr. et al. 2011, Zhang et al. 2018, Yang et al. 2024). Yang et al. state, “Cities that experience compact development tend to witness larger increases in extreme rainfall frequency over downtown than their rural surroundings, while the anomalies in extreme rainfall frequency diminish for cities with dispersed development.” While this is an important insight to consider, the effect on the specific stations used in this analysis is unknown, or at least not detectable in Fig. 6.5.5.

In summary, some regions show short-interval increases in extreme precipitation events, consistent with natural variability. But analysis of long term, nationwide historical records taking into account the autocorrelation properties of precipitation data does not support the claim that extreme short-duration rainfall events are becoming more frequent or intense.

6.5 Tornadoes

AR6 assesses tornado trends in the US as follows:

[O]bservational trends in tornadoes, hail, and lightning associated with severe convective storms are not robustly detected due to insufficient coverage of the long-term observations. There is *medium confidence* that the mean annual number of tornadoes in the USA has remained relatively constant. (Chapter 11, section 11.7.3, p. 1594)

The monitoring of weak tornadoes has changed over time. The growth of rural populations and the increasing ability to take video with hand-held devices has led to more frequent reports of weak tornadoes that produce minimal damage. In contrast, strong to violent tornadoes have been observed more consistently over time. Since statistics began in 1950, there has been a substantial decrease (by about 50%) in the number of strong to violent tornadoes as shown in Fig. 6.6.1a. Note that tornado strength is measured by the damage it produces, not by the visual appearance of the funnel. Limited real-time observational capabilities in earlier decades did not prevent identification because strong to violent tornadoes leave much more damage which will be assessed later even if the tornado itself was not observed.

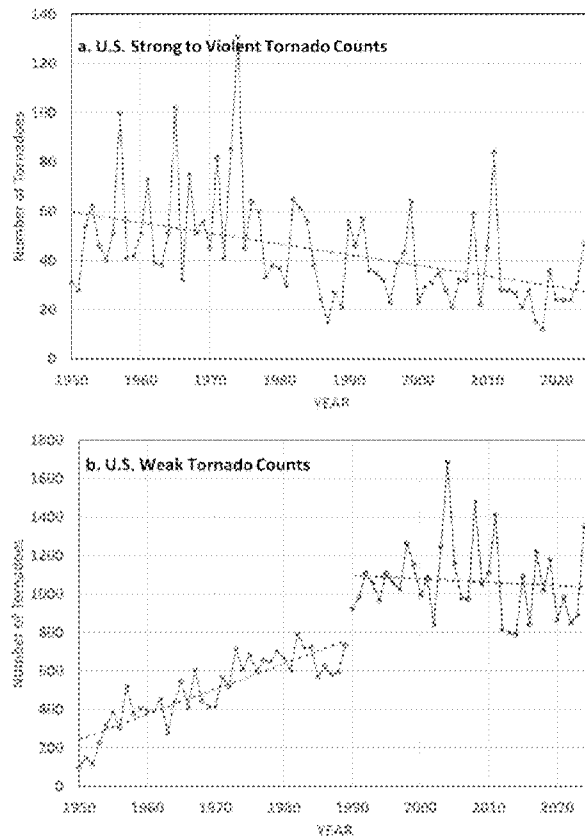


Figure 6.6.1. Annual U.S. tornado counts for (a) strong to violent tornadoes (EF3 to EF5), and (b) weak tornadoes (EF0 to EF2). Based upon NOAA Storms Prediction Center data, available at https://www.spc.noaa.gov/wcm/data/1950-2024_actual_tornadoes.csv

To summarize, there is a noticeable downward trend in the number of severe tornadoes in the U.S. since 1950. After 1990 the number of weak tornadoes in the U.S. has remained roughly constant; data before that are incomplete due to limited monitoring.

6.6 Flooding

Changes in floods were assessed as follows:

AR6: “The SREX assessed *low confidence* for observed changes in the magnitude or frequency of floods at the global scale. This assessment was confirmed by the AR5 report. The SR15 found increases in flood frequency and extreme streamflow in some regions, but decreases in other regions. . . [H]ydrological literature on observed flood changes is heterogeneous, focusing at regional and sub-regional basin scales, making it difficult to synthesise at the global and sometimes regional scales.” (Chapter 11.5)

AR6: “[T]he seasonality of floods has changed in cold regions where snowmelt dominates the flow regime in response to warming (*high confidence*). Confidence about peak flow trends over past decades on the global scale is *low*.” (Chapter 11.5)

NCA4: “Trends in extreme high values of streamflow are **mixed** across the United States. Analysis of 200 U.S. stream gauges indicates areas of both increasing and decreasing flooding magnitude **but does not provide robust evidence** that these trends are attributable to human influences” (pp. 240-241)

The absence of detectable US-wide trends in flooding is consistent with the findings in Section 6.5 of absence of coherent changes in extreme precipitation.

6.7 Droughts

Assessments of drought trends were as follows.

AR6: “**Few** AR6 regions show observed increases in meteorological drought” (Section 11.9, p. 1575),

AR6: “**Increasing trends in agricultural and ecological droughts have been observed on all continents** (*medium confidence*), but decreases only in one AR6 region (*medium confidence*). Increasing trends in hydrological droughts have been observed in a few AR6 regions.” (Chapter 11 Summary)

NCA4: “As a consequence of this increased precipitation, **drought statistics over the entire CONUS have declined.**” (p. 233)

NCA4: “Recent droughts and associated heat waves have reached record intensity in some regions of the United States; however, by geographical scale and duration, the Dust Bowl era of the **1930s remains the benchmark** drought and extreme heat event in the historical record (very high confidence).” (p.231)

SREX: “From a paleoclimate perspective, **recent droughts are not unprecedented**, with severe ‘megadroughts’ reported in the paleoclimatic record for Europe, North America, and Australia.” (p. 170)

As shown in Figure 6.8.1, US long term data shows an insignificantly declining trend toward extreme dryness (-0.001% per year)

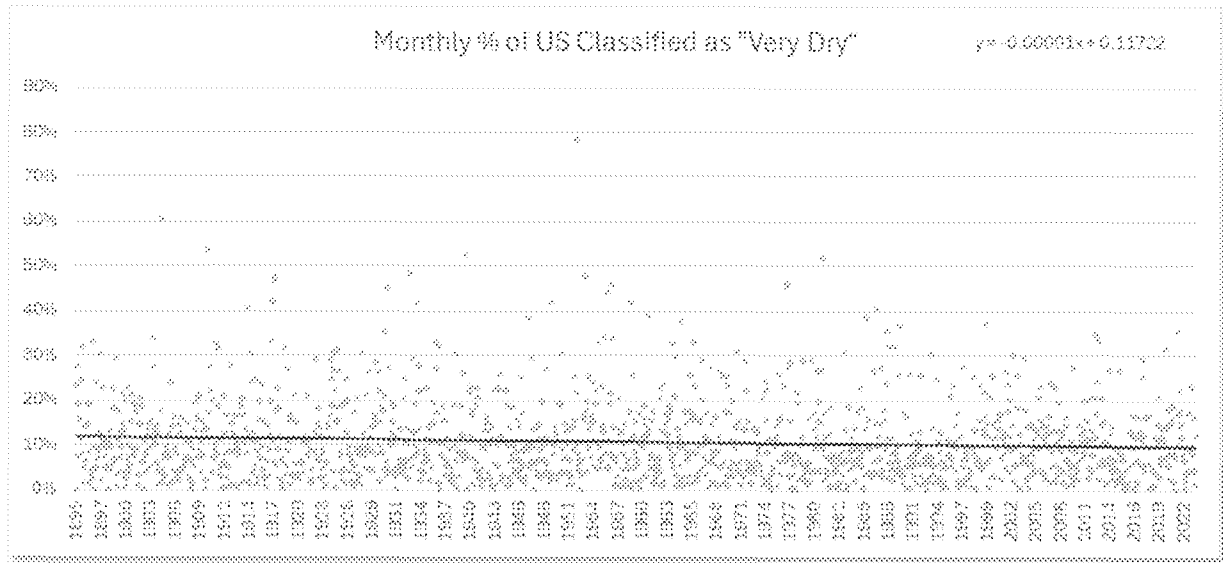


Figure 6.8.1: US dryness (%) 1895—2023. Source: NOAA
<https://www.ncei.noaa.gov/access/monitoring/uspa/wet-dry/0>

Kogan et al. (2020) examines a 38-year high-resolution satellite-based drought measure and concludes that global drought has not intensified and is not connected to climate change: “it is possible to state firmly that global and main grain countries’ drought area and intensity trends have not been following global climate warming since 1980’s.”

In summary there is no evidence of increasing drought frequency or intensity in the U.S. or globally over recent decades.

6.8 Wildfires

The IPCC has not provided an assessment of wildfires. As shown in Figure 6.9.1, global wildfire activity as measured by European Space Agency shows a downward trend in the 21st century.



Figure 6.9.1: Global wildfire area 2001-2018. Source: From Lizundia-Loiola et al. (2021). The different coloured lines represent data products derived from different satellites and algorithms

Global data show that wildfire coverage is constant or declining on every continent (Samborska and Ritchie, 2024).

Active fire suppression since 1900 makes it difficult to establish a natural baseline for wildfire activity in the U.S. Paleoclimatic evidence indicates that past activity was much higher than today. Marlon et al. (2012) used sedimentary charcoal layers to reconstruct fire history of western US for the past 1400 years and also fit a model to predict fire activity as a function of climatic conditions. Their results are summarized in Figure 6.9.3 below (from Figure 2 in their paper). There has been a growing wildfire deficit over the 20th century. In other words, however much fire was observed in the 20th century, it was less than what would have been observed in previous centuries based on the climatic conditions. Parks et al. (2025) likewise find that despite the recent increase in wildfire burn area in North America, a significant wildfire deficit remains relative to historical wildfire regimes.

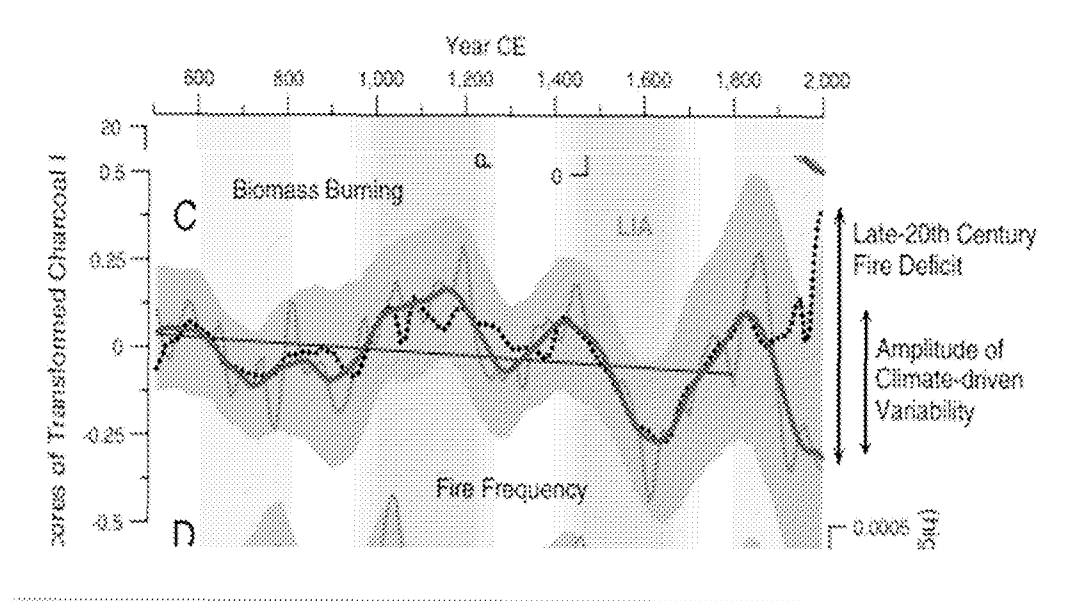


Figure 6.9.2 Fire frequency and fire deficit in the US. The red line shows the smoothed charcoal record and the black dotted line shows the predicted charcoal record based on climatic conditions. Source: Copied from Marlon et al. (2012)

US data from the National Interagency Fire Centre (NIFC) from 1926 to 2023 are shown in Figure 6.9.2.

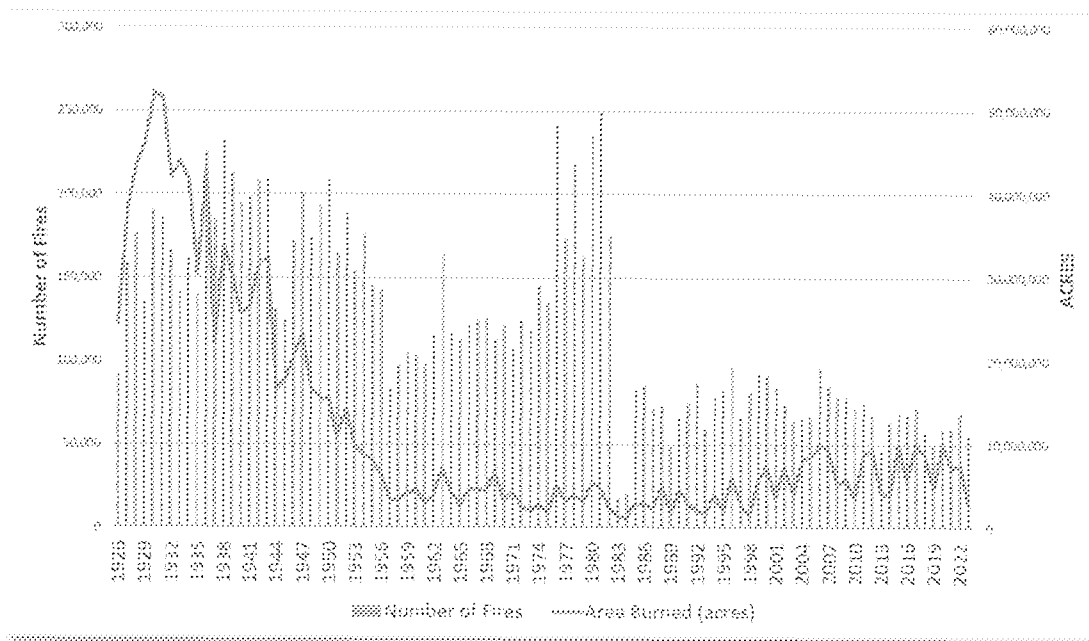


Figure 6.9.2: US wildfires 1926 to 2023. Source: Post-2018: National InterAgency Fire Center data

Pre-2017 webarchive.org.

The NIFC has removed the pre-1960 data from its current website on the grounds that measurement methods changed after 1960 making the comparison unreliable. Nonetheless just focusing on the post-1985 interval the number of fires is not increasing. The area burned did increase but only until about 2007.

Forest fires have always been a part of nature, and they can certainly create conditions that are inhospitable in the short term for all life including humans. Science has confirmed the overall benefit and necessity of the occurrence of forest fires. While recent high-profile fires and seasons serve as a reminder of the potential destructive impact, the highest profile forest fire remains the 1910 Big Blowup fire which destroyed over three million acres including the elimination of entire towns like Taft, MT (Apple, 2020). The 1910 fire reshaped the U.S. Forest Service (National Forest Foundation 2022) leading to a focus on fire suppression with a primary goal to defeat all forest fires (Forest History Society, 2022). This led to the 10 am rule in 1935 requiring that all fires spotted on any day had to be controlled by 10 am the following day (National Forest Foundation, 2022).

While defeating all fires seemed a noble goal, questions began to arise as to whether this behavior “followed the science” (US Forest Service, 2022). Over time the U.S. Forest Service has begun to rethink its goals, recognizing that new approaches such as prescribed burns, fuel elimination, and controlled wildfires are more appropriate (Sommer, 2016). Recent research is validating this approach and recognizing that more frequent smaller fires likely result in the healthier forests, water ecosystems and biodiversity (Stephens et al., 2021).

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7 CHANGES IN SEA LEVEL

Chapter Summary

Since 1900, global average sea level has risen by about 8 inches. Sea level change along U.S. coasts is highly variable, associated with local variations in processes that contribute to sinking and also ocean circulation patterns. The highest levels of sea level rise along U.S. coasts are Galveston, New Orleans, and the Chesapeake Bay regions - each of these locations is associated with substantial local land sinking (subsidence) unrelated to climate change.

Extreme projections of global sea level rise are associated with an implausible extreme emissions scenario and inclusion of poorly understood processes associated with hypothesized ice sheet instabilities. In evaluating the IPCC AR6 projections to 2050 (with reference to the baseline period 1995-2014), almost half of the sea level rise has already occurred by 2025 and at a lower rate than predicted. US tide gauge measurements shown herein reveal no obvious acceleration beyond the historical average rate of sea level rise.

7.1 Global sea level rise

Global sea level rise is arguably the most important climate impact driver that is unambiguously associated with increasing temperatures. At the global level, warming raises sea level through thermal expansion of the volume of sea water and through melting of glaciers and ice sheets. Variations in land water storage are another important factor. At the regional scale, sea level change is influenced by large-scale ocean circulation patterns, and geologic processes and deformation from the redistribution of ice and water. Locally, vertical land motion from geologic processes, ground water withdrawal, and fossil fuel extraction are also important.

The IPCC AR6 estimates that global mean sea level increased by 7.9 (5.9–9.8) inches between 1901 and 2018, with the rate of sea level rise accelerating in recent decades. At the ocean basin scale, sea levels have risen fastest in the Western Pacific and slowest in the Eastern Pacific over the period 1993–2018 (Fox-Kemper et al., 2021). The rate of global sea level rise is estimated to be 0.12 inches/year (for reference, 0.12 in is the height of two stacked pennies) (NASA, 2020).

The observing systems for global sea level rise have advanced significantly in the satellite era, particularly with the advent of satellite altimeters since 1993. Local tide gauges have provided useful data for the past century, and even longer for a few locations. Following the end of the Little Ice Age in the mid-nineteenth century, tide gauges show that the global mean sea level began rising during the period 1820–1860, well before most anthropogenic greenhouse gas emissions.

7.2 U.S. sea level rise

Observed and predicted rates of mean global sea level rise might have little scientific relevance for specific locations, owing to local processes (NOAA, 2025). Figure 7.1 shows that in Canada and Alaska (and also northern Washington), sea level is actually decreasing, owing to uplift from glacial rebound. Most of the Pacific coast tide gauges show rises between 0.12 inches/year, while largest U.S. rates are on the Gulf coast (Louisiana and Texas) and in the mid-Atlantic states (Chesapeake Bay region).

Measurements of relative sea level rise from tide gauges conflate the climatologically relevant increase in the volume of seawater with local vertical land motion. That latter, which varies from place to place, is

best measured using a Global Positioning System (GPS) station located near the tide gauge. It is driven by a range of processes that can be comparable to the climate signal and can locally exacerbate (subsidence/sinking) or mitigate (uplift) the risk of sea level rise (Wöppelmann and Marcos, 2016). Human activities triggering subsidence are often significant. They include soil drainage (e.g. for urban development purposes) and subsurface extraction of groundwater, oil, or gas.

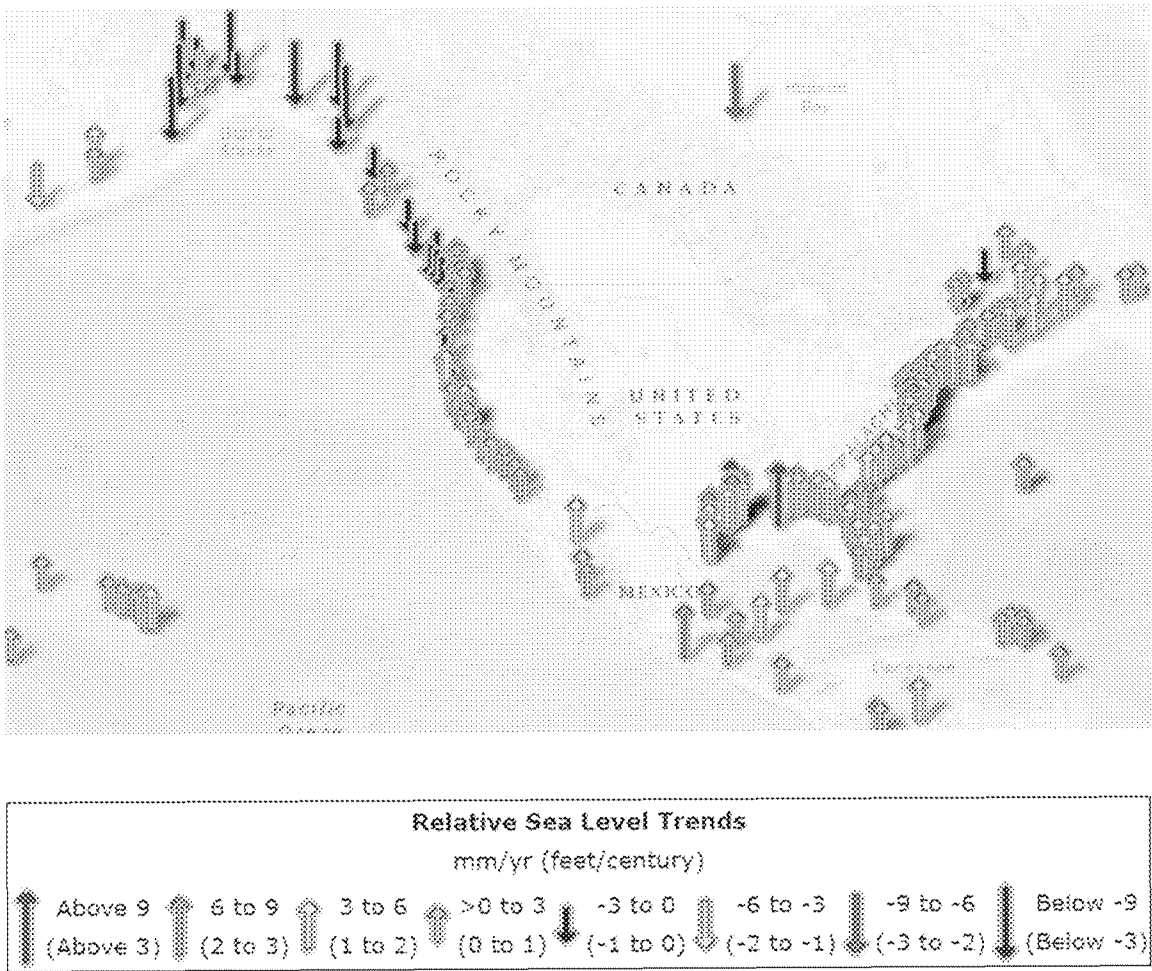


Figure 7.1. Map of rates of relative sea level rise along the U.S. coast (NOAA, <https://tidesandcurrents.noaa.gov/sltrends/>). For reference, 3 mm = 0.12 in.

Table 7.1 shows absolute sea-level rise (ASLR) for selected locations, determined from the sum of uncorrected sea-level rise as estimated from tide gauge time series (RSLR) (NOAA, 2025) and the vertical land motion (VLM) measurements (NAS, 2012; Letetrel et al., 2015; Karegar et al., 2016). The absolute sea level rise for each of these locations is significantly smaller than the measured relative sea level rise owing to local subsidence. More than half of the measured relative sea level rise is attributed to land sinking for these locations: San Francisco, Galveston, Grand Isle. For reference, the global average rate of absolute sea level rise is estimated to be 0.12 inches/year.

Location	RSLR	VLM	ASLR
San Francisco, CA	+0.08	-0.06	+0.02
Galveston, TX	+0.26	-0.19	+0.07
Grand Isle, LA	+0.36	-0.28	+0.08
St Petersburg, FL	+0.12	-0.02	+0.10
New York City, NY	+0.11	-0.05	+0.06

Table 7.1 Absolute sea level rise (inches/year) (Relative Sea Level Rise (RSLR) plus Vertical Land Motion (VLM))

San Francisco Bay

Over the past 100 years, relative sea level in the San Francisco Bay area has risen by 7.8 inches, at an average rate of 0.08 inches/year (Figure 7.2). As shown in Table 7.1, San Francisco's vertical land motion is -0.06 inches/year (sinking), producing a recent absolute rate of +0.02 inches/year. Portions of Treasure Island, San Francisco International Airport, and Foster City are sinking as fast as 0.4 inches/year (Shirzaei and Bürgmann, 2018). Problems in the San Francisco Bay area, including threats to the airport, have been caused primarily by soil compaction in landfill zones that were formerly wetlands, not by the slow creep of global sea level rise.

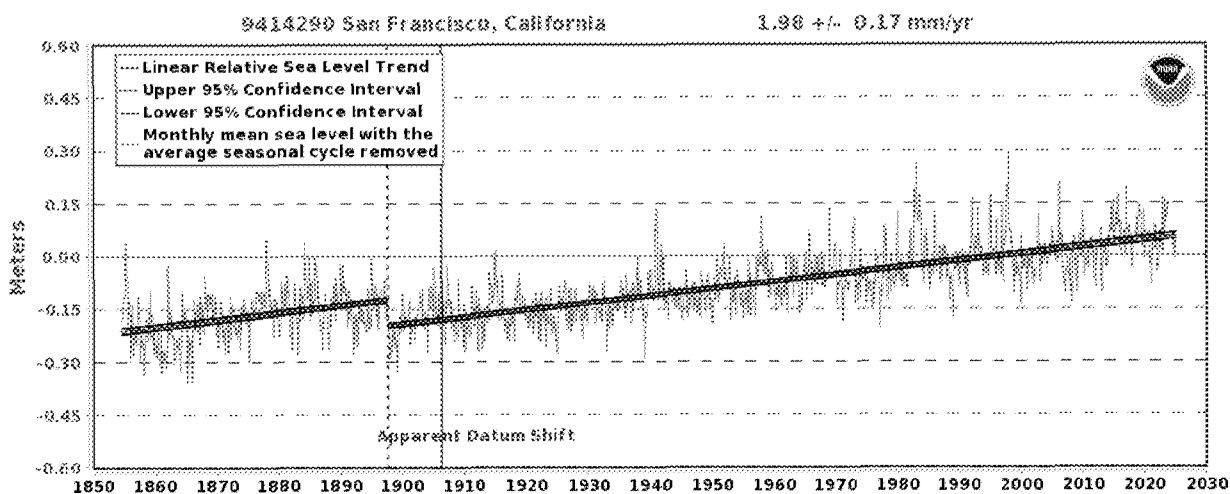


Figure 7.2. Tide gauge measurements at San Francisco, California, obtained from NOAA - https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=9414290 (downloaded 4/22/25).

Galveston - Houston

Long-term tide measurements at Galveston Pier 21 show sea level rise of 2.18 feet in the past century, or a rate of 0.26 inches/year (Figure 7.3). Vertical land motion (subsidence) at Galveston is estimated at -0.19 inches/year, yielding an absolute rate of rise of +0.07 inches/year (Table 7.1). The U.S. Geologic Survey found that most of the land-surface subsidence in the Houston-Galveston region is a direct result of groundwater withdrawals (Kasmarek and Ramage), which caused compaction of the aquifer sediments, mostly in the fine-grained silt and clay layers. By 1979, as much as 10 feet of subsidence had occurred in Houston.

Hurricanes have been the major concern in the region. The 1900 hurricane that struck Galveston and killed between 6,000 and 12,000 people is still considered the deadliest U.S. natural disaster (Weems, 2016). Hurricane Ike (2008) decimated large portions of the Bolivar Peninsula, literally removing significant portions of the land mass (UCS, 2017). While only 17 people were killed in Texas, property damage exceeded \$50 billion (White, 2017). In 2017, Hurricane Harvey struck the region, bringing catastrophic rainfall-triggered flooding that inflicted over \$125 billion in damages (NOAA, 2025).

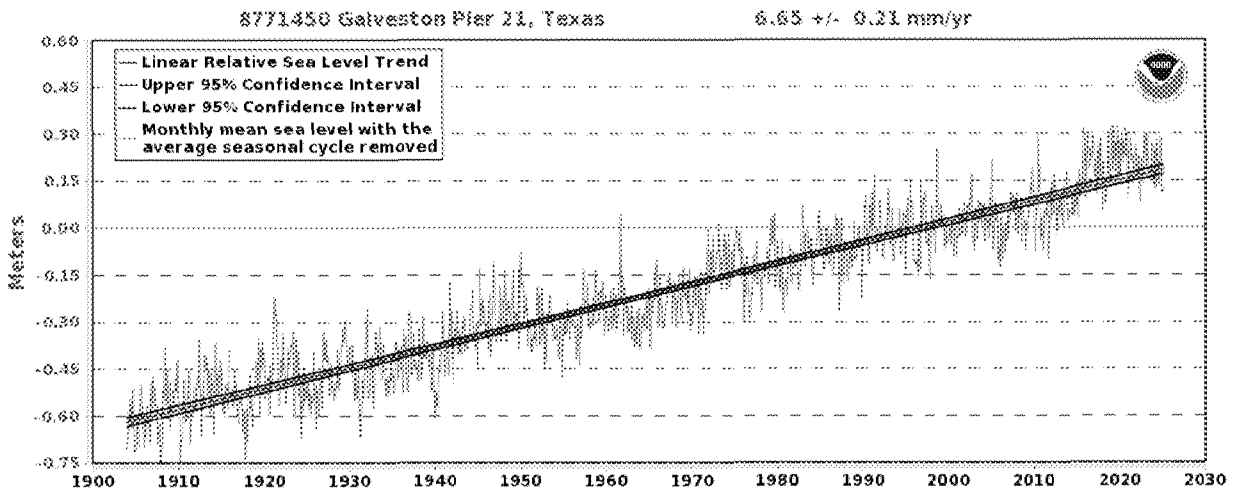


Figure 7.3. Tide gauge measurements Galveston Pier, TX, obtained from NOAA - https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8771450 (downloaded 4/22/2025).

New Orleans and the Mississippi delta

Long-term tide gauge measurements at Grand Isle, Louisiana, show that sea level has risen by slightly more than 3 feet over the last 100 years at an average rate of 0.36 inches/year (Figure 7.4). Vertical land motion (subsidence) is estimated -0.28 inches/year. Table 7.1 gives the absolute sea level rise as +0.08 inches/year.

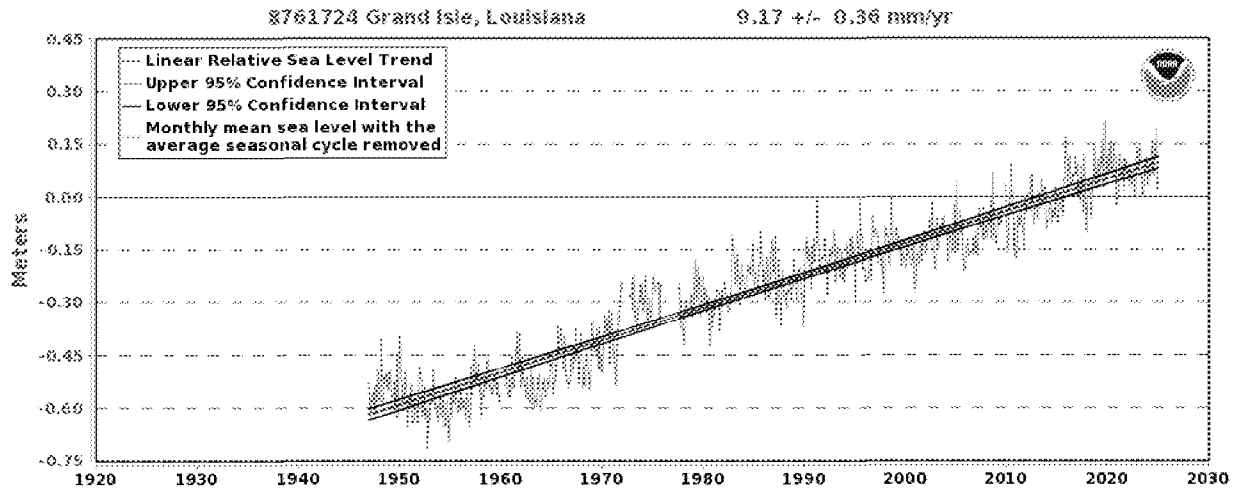


Figure 7.4. Tide gauge measurements at Grand Isle, LA, obtained from NOAA - https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8761724 (downloaded 4/22/25).

The issues of sea level rise and land loss in the Mississippi Delta region are complex, with geological subsidence and the decline in sediment transported by the Mississippi river being the dominant drivers. The construction of dams in the basin since the 1950s has decreased the Mississippi's suspended sediment load by ~50% (Maloney 2018). A new subsidence map of coastal Louisiana finds the coastal region to be sinking at about one third of an inch per year (Neinhuis et al. 2017), associated with groundwater and resource withdrawal. As the city's elevation averages one to two feet *below* sea level, sea level rise from anthropogenic warming is hardly the dominant driver of New Orleans' problems.

New York City

New York City is particularly vulnerable to the effects of sea level rise because it is built primarily on islands and has 520 miles of coastline. Measurements by a tide gauge at the southern tip of Manhattan (The Battery) show that relative sea level has risen over 11 inches over the past century, at an average rate of 0.11 inches/year (Figure 7.5). But vertical land motion in the New York City area is -0.05 inches/year (roughly 5 inches per century), so that the absolute rate of sea level rise at The Battery is 0.06 inches/year, or about 55% of the measured relative sea level rise.

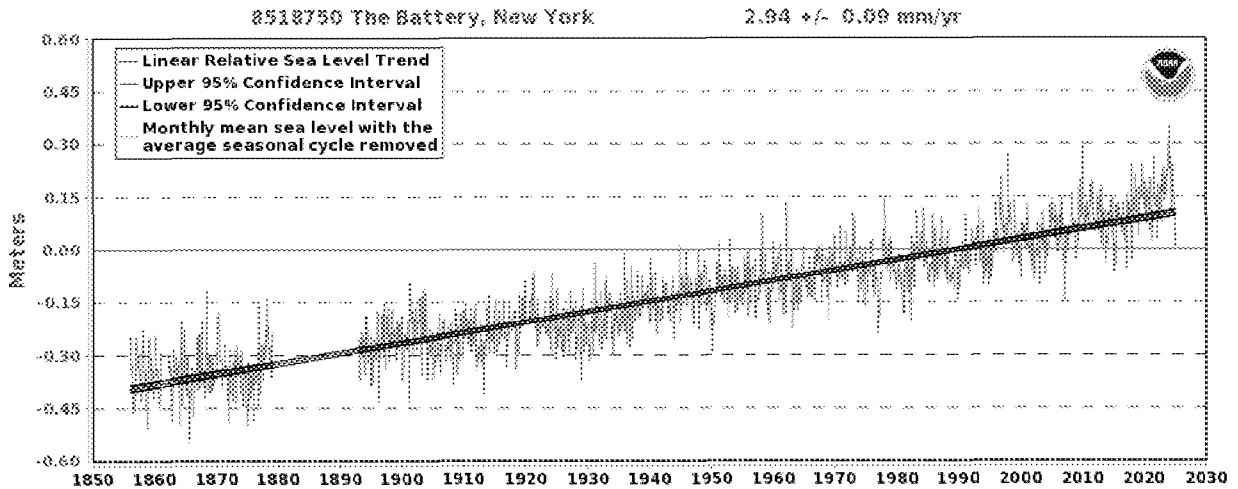


Figure 7.5. Tide gauge measurements at The Battery, New York, obtained from NOAA - https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8518750 (downloaded 4/22/25).

Following Superstorm Sandy, New York developed a comprehensive plan: *City of New York: Building a Stronger, More Resilient New York* (CNY, 2013). A broad range of coastal protection measures are outlined that match the risks facing the various zones: increase coastal edge elevations, minimize upland wave zones, infrastructure to protect against storm surge, improve coastal design and governance, restore estuaries wetlands, coastal nourishment, site elevation, and drainage systems.

7.3 Projected sea level rise

The concern over sea level rise is not about the roughly 8 inches of global rise since 1900. Rather, it is about projections of *accelerated* rise based upon simulations of a warming climate through the 21st Century.

The IPCC AR6 finds *high agreement* across published global mean sea level projections for 2050 with little sensitivity to emissions scenarios. Considering only projections incorporating ice-sheet processes in whose quantification there is at least *medium confidence*, the global sea level projections for 2050, across all emissions scenarios, fall between 3.94 and 15.75 inches (5th–95th percentile *very likely* range) relative to the 1995–2014 baseline period (Fox-Kemper et al., 2021).

Conversely, AR6 states there is *low agreement* across published global mean sea level projections for 2100, particularly for higher emissions scenarios. Considering only projections representing ice sheet processes in whose quantification there is at least *medium confidence*, the AR6 global mean sea level projections for 2100 lie between 7.87 and 39.37 inches (5th–95th percentile *very likely* range) under the medium emissions scenario SSP2–4.5 (Fox-Kemper et al., 2021). There is deep uncertainty surrounding projections of sea level rise to 2100, particularly for the higher emissions scenarios.

In evaluating the IPCC AR6 projections to 2050 (with reference to the baseline period 1995-2014), almost half of the sea level rise has already occurred by 2025. From the tide gauge measurements in Figures 7.2-7.5, there is no obvious acceleration in sea level rise beyond the historical average rate of sea level rise.

In February 2022, NOAA issued its projections of sea level rise for various sites along the US coast (Sweet et al, 2022). They claim that by 2050, the sea will have risen one foot at The Battery in Manhattan. A one foot rise in thirty years would be more than twice the current rate and about three times the average rate over the past century. In that historical context, NOAA’s projection is remarkable—as shown in Figure 7.6, it would require a dramatic acceleration beyond anything observed in the early 20th century. But even more noteworthy is that they say this rise is “locked in”—it will happen no matter what future emissions are. We should know in a decade or so whether that prediction has legs.

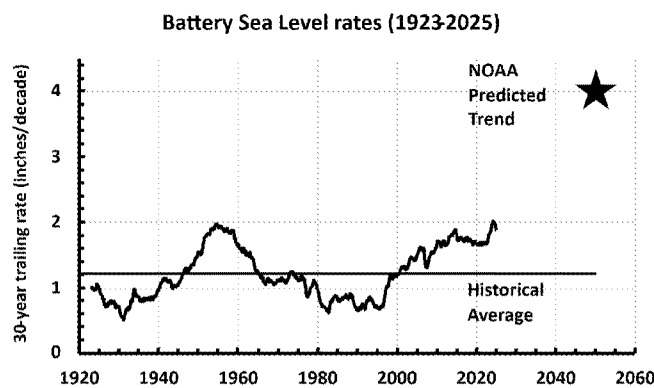


Figure 7.6 Rate of sea level rise at the Battery in Manhattan. Shown is the historical thirty-year trailing trend, together with the allegedly “locked in” NOAA predicted trend for 2050. Historical data: NOAA Tides and Current.

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MISSING REFERENCE: White 2017

8 UNCERTAINTIES IN CLIMATE CHANGE ATTRIBUTION

Chapter summary

“Attribution” refers to determining cause regarding some aspect of climate change, specifically with reference to anthropogenic activity. There is an ongoing scientific debate around attribution methods, particularly regarding extreme weather events. Attribution is made difficult by high natural variability, the relatively small expected anthropogenic signal, lack of high-quality data, and reliance on deficient climate models. The IPCC has long cautioned that methods to establish causality in climate science are inherently uncertain and ultimately depend on expert judgement.

Substantive criticism of the main IPCC assessments of the role of CO₂ in recent warming focus on inadequate assessment of natural climate variability, uncertainties in measurement of solar variability and aerosol forcing, and problems in the statistical methods used for attribution.

The IPCC does not in general make attribution claims for most climate impact drivers related to extreme events. Statements related to statistics of global extremes (e.g. event probability or return times, magnitude and frequency) are not generally considered accurate owing to data limitations and are made with low confidence. Attribution of individual extreme weather events is challenging due to their rarity. Conflicting claims about the causes of the 2021 Western North America Heatwave illustrate the perils of hasty attribution claims about individual extreme events.

8.1 Introduction

The Intergovernmental Panel on Climate Change (IPCC) distinguishes between detection of climate change and attribution of its cause. As defined by the IPCC AR6 WGI Glossary (IPCC, 2025):

Detection: “Detection of change is defined as the process of demonstrating that climate or a system affected by climate has changed in some defined statistical sense, without providing a reason for that change. An identified change is detected in observations if its likelihood of occurrence by chance due to internal variability alone is determined to be small, for example, <10%.”

Attribution: “Attribution is defined as the process of evaluating the relative contributions of multiple causal factors to a change or event with a formal assessment of confidence.”

Both steps rely on statistical analysis. Detection focuses on whether changes are significant enough to stand out from random variation regardless of cause. Attribution involves comparison of observed events to model-generated counterfactuals. Since experimentation on the climate is not possible, attribution requires statistical inference to assess how much human activities, such as GHG emissions, versus natural factors, like volcanic eruptions, contribute to observed changes. Attribution methods assume all external and internal drivers of the system are known and represented.

There are ongoing scientific debates around attribution methods, especially those for attributing extreme weather events to climate change. The IPCC has long cautioned that methods to establish causality in climate science are inherently uncertain and ultimately depend on expert judgement. AR4 Working Group I (Hegerl et al., 2007) explained it as follows:

‘Attribution’ of causes of climate change is the process of establishing the most likely causes for the detected change with some defined level of confidence... unequivocal attribution would require controlled experimentation with the climate system. Since that is not possible, in practice attribution of anthropogenic climate change is understood to mean demonstration that a detected change is ‘consistent with the estimated responses to the given combination of anthropogenic and natural forcing’ and ‘not consistent with alternative, physically plausible explanations of recent climate change that exclude important elements of the given combination of forcings’ (IPCC, 2001)... The approaches used in detection and attribution research described above cannot fully account for all uncertainties, and thus ultimately expert judgement is required to give a calibrated assessment of whether a specific cause is responsible for a given climate change.

AR5 Working Group II (Cramer et al., 2014) makes the following statement:

“Two broad challenges to the detection and attribution of climate change impacts relate to observations and process understanding. On the observational side, high-quality, long-term data relating to natural and human systems and the multiple factors affecting them are rare. In addition, the detection and attribution of climate change impacts requires an understanding of the processes by which climate change, in conjunction with other factors, may affect the system in question.”

Because of the complexity of the causal chains in the climate system, investigation of these relationships is exceptionally challenging.

8.2 Attribution methods

The IPCC employs several attribution methods to assess the causes of observed climate changes, distinguishing between natural and human-induced factors. Below is a concise description of the key methods that have been used by the IPCC.

Optimal Fingerprinting uses linear regression to explain variations in observed climate data as a weighted sum of climate model simulations run with and without anthropogenic forcings. The data used in the regression model are weighted to try to minimize the influence of random noise and the estimation method is chosen to take account of climate model error.

Time Series Analysis exploits statistical differences between anthropogenic forcing and natural variability to see which dominates observed temperatures, and also uses variations in the timing of changes to determine if causal dependence across data series can be inferred.

Process-Based Attribution focuses on understanding the physical mechanisms behind observed changes. This approach combines observations, climate models, and theoretical understanding to attribute changes in specific processes to forcings. This approach is often used for regional climate phenomena, such as monsoon changes or polar amplification

Extreme Event Attribution assesses in the role of human influence in the likelihood of occurrence or intensity of extreme weather events (e.g. heat waves, droughts). Methods include:

- Probabilistic Event Attribution uses large ensembles of climate model simulations to compare observed events to model-generated counterfactuals

- Storyline Approach examines the physical processes driving an event and evaluates how anthropogenic forcings might have modified those processes

8.3 Attribution of global warming

Attribution statements for global warming in the three most recent IPCC Assessment reports are:

AR4: “Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.” (IPCC 2007)

AR5: “It is *extremely likely* that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together. The best estimate of the human-induced contribution to warming is similar to the observed warming over this period.” (IPCC 2013)

AR6: “The *likely* range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C. It is *likely* that well-mixed GHGs contributed a warming of 1.0°C to 2.0°C, other human drivers (principally aerosols) contributed a cooling of 0.0°C to 0.8°C, natural drivers changed global surface temperature by –0.1°C to +0.1°C, and internal variability changed it by –0.2°C to +0.2°C. It is *very likely* that well-mixed GHGs were the main driver of tropospheric warming since 1979.” (IPCC 2021)

The AR4 and AR5 attribution statements reference the warming since the mid-20th century, the period when greenhouse gas emissions began rapidly increasing. The words “most” and “more than half” are deliberately imprecise, potentially ranging from 51 to 99% of the warming – presumably this imprecision is to account for structural uncertainties such as natural internal variability. The confidence level increases from *very likely* to *extremely likely* from AR4 to AR5. The structure of the attribution statement in the AR6 is fundamentally different, referencing the warming to the period 1850-1900. The AR6 attribution statement is more precise numerically, but with a lower level of confidence at “likely” – the AR6 attributes essentially all the warming to increases in greenhouse gases. The most confident statement from the AR6 relates to the tropospheric warming since 1979, using the words “main driver” and “*very likely*.”

There are three areas of substantive criticism of the IPCC’s assessment of the causes of the recent warming: inadequate assessment of natural climate variability, inappropriate statistical methods, and substantial discrepancies between models and observations. The last is discussed in Chapter 6, while this chapter discusses the first two factors. All of these criticisms are relevant to the IPCC’s policy-informing attribution of the recent warming, which also underpins extreme event attribution

8.3.1 Natural climate variability

IPCC AR6 states that natural external drivers since 1850-1900 have changed global surface temperature by –0.1°C to +0.1°C, and internal variability has changed it by –0.2°C to +0.2°C – on average having essentially no net impact on the warming since 1850-1900. As discussed below, this minimal contribution of natural variability has been disputed by several publications that question the magnitudes of solar variability and internal variability from large-scale ocean circulation.

Solar variability

IPCC AR5 concluded that the best estimate of radiative forcing due to Total Solar Irradiance (TSI) changes over the period 1750–2011 was very small (0.05 W/m^2 , Myrhe et al., 2014). IPCC AR6 acknowledges a much larger range of estimates of changes in TSI over the last several centuries, stating that the TSI between the Maunder Minimum (1645–1715) and the second half of the twentieth century increased by $0.7\text{--}2.7 \text{ W/m}^2$, a range that includes both low and high variability TSI data sets (Gulev, 2021). However, the recommended forcing dataset for the CMIP6 climate model simulations used in AR6 for attribution studies averages two data sets with low solar variability (Matthes, 2017).

While AR6 shows a substantially greater solar impact than does AR5, the overall impact on the climate was still assessed to be small compared to anthropogenic forcing of climate change. However, the impact of solar variations on the climate is uncertain and subject to substantial debate - something that is not evident from the IPCC assessment reports (Lockwood, 2012; Connolly et al., 2021).

The change of TSI over time remains a challenging problem.. Since 1978, there have been direct measurements of TSI from satellites. However, the data exhibits non-negligible inconsistencies, and interpreting any multi-decadal trends in TSI requires comparisons of observations from overlapping satellites. There are several rival composite TSI datasets, disagreeing as to whether TSI increased or decreased during the period 1986–96 (the ACRIM gap; see Chapter 4). Further, the satellite record of TSI is used to calibrate proxy models, whereby past solar variations are inferred from sunspots and cosmogenic isotope measurements (Velasco Herrera et al., 2015).

There is substantial evidence for high solar activity in the second half of the 20th century (starting in 1959) and extending into the 1990's, before a decline in the early 21st century; this period is often termed the “Modern Maximum.” (Chatzistergos et al., 2023; Solanki et al., 2004; Usoskin et al., 2007). However, some scientists have concluded that it is not possible to be confident of any multi-decadal trend in TSI (Schmutz, 2021).

This uncertainty causes some reconstructions of TSI from 1750 to have low variability (implying a very low impact of solar variations on global mean surface temperature) whereas datasets with high TSI variability can explain more than 70% percent of the temperature variability since preindustrial times (Scafetta, 2013; Stefani, 2021). The choice of TSI satellite record used in an analysis can therefore substantially influence how much climate change is attributed to human versus natural forcings.

There is growing evidence that other aspects of solar variability, which are referred to as solar indirect effects, either amplify TSI forcing or are independent of TSI forcing. Scafetta et al. (2023) suggests that ~80% of solar influence on climate may stem from non-TSI mechanisms. There are numerous candidate processes, including solar ultraviolet changes; energetic particle precipitation; atmospheric-electric-field effect on cloud cover; cloud changes produced by solar-modulated galactic cosmic rays; large relative changes in the magnetic field; and the strength of the solar wind. Such solar indirect effects are not included in climate models, although indirect methods of estimating their impacts suggest they are significant. However, claims of non-TSI mechanisms influencing climate are uncertain and debated.

Natural variability of large-scale ocean circulations

Variations in global mean surface temperature are linked to recurrent large-scale variations in ocean circulation patterns, including the Atlantic Multidecadal Oscillation (AMO), the Pacific Decadal Oscillation (PDO) and the El Nino-Southern Oscillation (ENSO). These circulations influence ocean heat uptake and heat distribution, and also influence atmospheric circulation patterns and cloud distributions. There is some debate as to whether these variations are strictly internal to the climate system, or whether this variability can have a solar/astronomical origin or can be influenced by large volcanic eruptions.

While climate models simulate the large-scale ocean circulations and internal climate variability, most models show have too little amplitude compared to observations at multi-decadal frequencies and phasing out-of-sync with the observed climate (Kravtsov et al. 2024). Averaging multiple simulations effectively averages out the internal variations, leaving only the forced climate variability (e.g., CO₂ forcing). With most of the modern warming beginning in the late 1970's, the recent 50-year warming is on the same time scale as the multi-decadal oscillations of the AMO and PDO.

Here are summary statements from the IPCC AR5 and AR6 reports:

“Decadal variability in the Pacific, associated with the PDO or IPO [Interdecadal Pacific Oscillation], contributes significantly to regional and global temperature trends, but the relative contributions of internal variability and external forcing are difficult to disentangle in CMIP5 simulations.” (IPCC, 2013)

"Since AR5, there has been increased understanding of the role of internal variability, such as ENSO, PDO, and AMO, in modulating regional climate trends. However, limitations in simulating the exact timing and amplitude of these modes in CMIP6 models contribute to uncertainties in attributing observed changes to anthropogenic forcing (*high confidence*).” (IPCC, 2021)

The amplitude of the peak-to-trough impact of the multi-decadal oscillations on global temperatures has been assessed by the IPCC AR6: “The likely range of change due to internal variability is -0.2°C to +0.2°C (IPCC, 2021).” This implies a trough-to-peak change of 0.4°C. Over many centuries, any global temperature changes from the troughs and peaks will cancel out, with little to no net impact.

However, with a nominal timescale of 60-80 years for oscillations such as the AMO and PDO, the timing of the peaks and troughs can be confused with the secular trend. This becomes very relevant for attributing the warming for the past 50 years, when most of the recent warming has occurred. Even if climate models have the correct amplitude of the multidecadal oscillations, the timing of the peaks and troughs is not adequately simulated, with each model and individual ensemble simulating a different phasing. Once the simulations of the ensemble members and different models are averaged, the natural internal variability contribution is averaged out, effectively cancelling the role of natural internal variability in the attribution process.

The time series of global surface temperature anomalies since 1850 (Figure 8.1) shows irregular variations of significant amplitude against the background of an overall warming trend and, after 1976, a pronounced difference in trends between the Northern Hemisphere and the Southern Hemisphere. The period between 1905-1945 shows a strong trend of warming. The following thirty years from 1945-1976 showed slightly declining temperatures. The most recent warming period started in 1977.

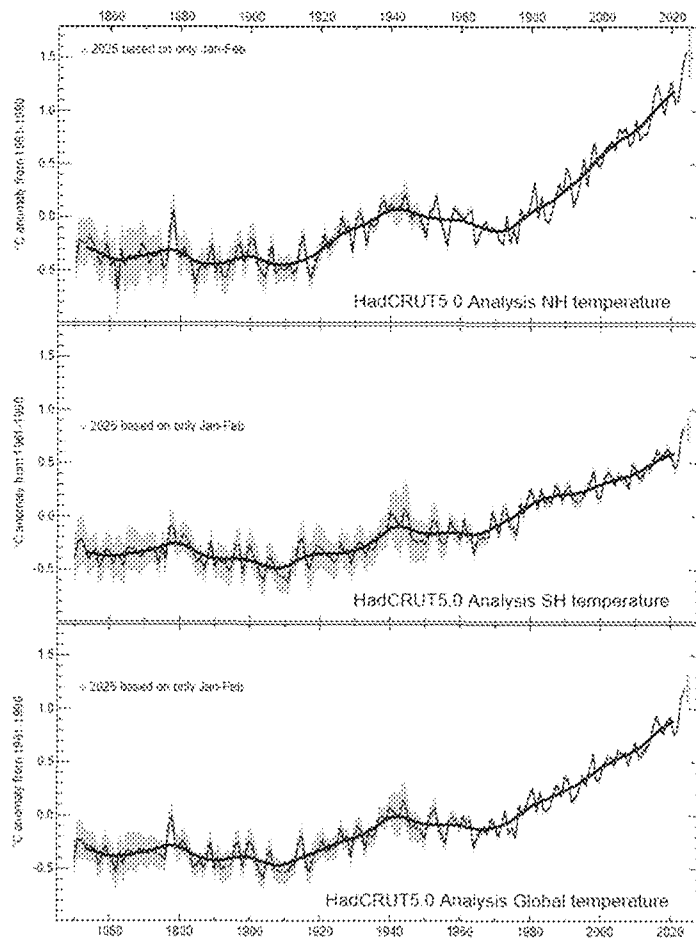


Figure 8.1 Global average surface temperature anomalies 1850—2025. Top: Northern hemisphere. Middle: Southern hemisphere. Bottom: Global average. Source: UK Hadley Centre <https://crudata.uea.ac.uk/cru/data/temperature/HadCRUT5.0Analysis.pdf>

The causes of the early 20th century warming are discussed by Hegerl et al. (2017; 2019). The atmospheric CO₂ concentration increased from 298 ppm in 1905 to 310 ppm in 1941; hence this implies that CO₂ had little impact on the warming. Volcanic activity during this period was very low, and solar forcing is uncertain. Hegerl et al (2017) somehow inferred that 40-54% of this warming could be attributed to external forcing, with the rest associated with internal variability. Bronniman et al (2024) focused on the causes of the cooling in the first decade of the 20th century in the Southern Hemisphere. They found that the cooling was related to a La-Niña-like pattern in the Pacific, a cold tropical and subtropical South Atlantic, a cold extratropical South Pacific, and cool southern midlatitude land areas. The Southern Annular Mode was positive, with a strengthened Amundsen–Bellingshausen seas low, although the spread of the data products is considerable.

The warming in the 1930's and subsequent cooling during mid century was particularly pronounced in the Arctic. Bokuchava and Semenov (2021) find that most likely these variations were caused by a combined effect of long-term natural climate variations in the North Atlantic and North Pacific with a contribution of the natural radiative forcing related to the reduced volcanic activity and variations of solar activity as well as growing greenhouse gases concentrations. Tokinaga et al (2017) showed that the combined effect of internally generated Pacific and Atlantic interdecadal variability intensified Arctic

warming in the early 20th century. The synchronized Pacific-Atlantic warming drastically alters planetary-scale circulations over the Northern Hemisphere; these same circulation patterns have a global influence.

The cooling period between 1945 and 1976 has been referred to as the “grand hiatus.” Numerous causes have been hypothesized: natural internal variability from fluctuations associated with the Pacific Decadal Oscillation (PDO) and Atlantic Multidecadal Oscillation; cooling from increased emissions of aerosols from industrial activities; increased heat uptake in the Atlantic, Southern and Equatorial Pacific Oceans. Thompson et al. (2010) find that the hemispheric differences in temperature trends in the middle of the twentieth century stem largely from a rapid drop in Northern Hemisphere sea surface temperatures of about 0.3 °C between about 1968 and 1972.

The Great Pacific Climate Shift of 1976-1977 was a notable climatic event characterized by an abrupt change in the North Pacific Ocean's atmosphere-ocean system that interacted with global climate patterns. This shift is closely associated with the Pacific Decadal Oscillation (PDO) that oscillates between warm and cool phases over decades. The 1976 shift marked a transition from a predominantly negative (cool) PDO phase (1947–1976) to a positive (warm) phase (1977 through 2000), with significant implications for global and regional climate patterns including the frequencies of El Nino and La Nina events. The Great Pacific Climate Shift coincided with the beginning of a period of accelerated global warming. When the Great Pacific Climate Shift is accounted for in climate attribution analyses since 1950, 40 percent or more of the warming in the second half of the 20th century is attributed to natural internal variability (McLean et al., 2009; Tung and Zhou, 2013; Chylek et al., 2016; Scafetta, 2021).

8.3.2 *Optimal fingerprinting*

Optimal fingerprinting is a statistical technique introduced by Allen and Tett (1999) that compares observed climate data to climate model simulations to identify patterns (or “fingerprints”) associated with human or natural forcing. It involves taking a vector of observed climate changes, such as warming rates in locations around the world, and decomposing them into a weighted sum of “signals”, which are analogues to the observations generated by climate models with different types of forcings. The weights are chosen using a regression method called Total Least Squares. The analysis commonly uses just two signals, one generated by models using only anthropogenic forcings and one using only natural forcings. If the estimated weighting coefficient attached to a signal is significantly different from zero, then that signal is said to be “detected”. If it is close to 1.0, then the model generating the signal is said to be consistent with observations. If it is less than 1.0, then the model signal for that forcing is too strong and needs to be scaled down, and vice-versa. Both the observed data and the signals are weighted using a model-generated estimate of patterns of randomness in the climate system so as, in principle, to put maximum weight on regions where natural variability is minimized.

Optimal fingerprinting is the primary tool for attribution in the research literature. While it has been widely used and prominently featured by the IPCC since 2001 there is very little literature examining the statistical properties of the results it generates. One of its inherent weaknesses is that results depend on assumptions about the accuracy of climate models, especially regarding their representation of natural variability (IPCC AR5 Ch 10.2.3).

A series of papers by McKittrick (McKittrick 2021, 2022, 2023, 2025) has challenged the optimal fingerprinting method, arguing that it is inherently unreliable and that practices adopted from econometrics can provide more valid results. Statistical theory requires that for regression models to yield unbiased coefficients, a set of assumptions called the Gauss-Markov conditions must hold. McKittrick (2021) argued that the Allen and Tett (1999) methodology violates the Gauss-Markov conditions, leading to potentially biased and inconsistent fingerprinting coefficients, undermining the reliability of the method. Chen et al. (2023) confirmed this analysis and argued that the method could yield unbiased results but only under very stringent assumptions. McKittrick (2022) and (2023) raised a further concern that climate scientists—virtually alone among

scientific disciplines—have used an estimation method called Total Least Squares (TLS) to estimate anthropogenic greenhouse gas signal coefficients, despite its tendency to be unreliable unless some strong assumptions hold that in practice are unlikely to be true. Under conditions that easily arise in optimal fingerprinting, TLS yields estimates with large positive biases. Thus, any study that used TLS for optimal fingerprinting without verifying its applicability in the specific data context has likely overstated the result.

McKittrick (2025) presented an empirical example comparing the results of conventional optimal fingerprinting against methods drawn from mainstream econometrics that are known to be valid for the specific application of signal detection. While the IPCC optimal fingerprinting method yields an anthropogenic signal coefficient close to 1.0 on a global temperature data set spanning 1900 to 2010, consistent estimation yields a coefficient around 0.4, which rises to about 0.65 on data spanning 1980 to 2010, implying the model response to greenhouse gases needs to be scaled down by about half to optimally match observations. The natural forcing signal coefficient, by contrast, is between 2.0 and 4.0, implying the climate model signals of natural forcing need to be scaled up two-to four-fold to match observed climate change. The fingerprinting coefficients estimated in McKittrick (2025), when used to scale the average sensitivity of the climate models used to generate the forcing signals in his data set, imply a Transient Climate Sensitivity of 1.4°C, which is consistent with the estimate by Lewis (2023) using a different estimation method and multiple independent data sets.

While these analyses do not falsify all results stemming from the IPCC optimal fingerprinting method, they do challenge the basis on which they were believed to be correct.

8.3.3 Time series methods

The IPCC (AR5 WGI 10.2.2) drew attention to alternative approaches of assessing causality that emerged from the time series econometrics literature. These have the advantage of not depending on assumptions about the accuracy of climate models, but the disadvantage that they depend on difficult-to-test assumptions about the data generating process underlying climate and forcing data. The methods, now referred to as climate econometrics, use the tools of unit root testing, Granger causality and cointegration analysis, all of which are familiar in economics and finance and which are slowly being adopted in climate science. Time series analysis methods hold out the possibility of determining whether anthropogenic or natural forcings are the primary drivers of climate change without requiring the use of climate models, although key questions remain unsettled (e.g. Dergiades et al., 2016, Balcombe et al., 2019, Dagsvik et al., 2020, Razzak, 2022, Dagsvik and Moen, 2023).

“Granger causality” modeling is a tool for determining directions of influence in data series that move together. It is a statistical, not a physical, concept. If knowing the current value of one variable significantly improves the forecast accuracy of another variable we can infer a causal connection exists; this is called Granger causality. The modeling tools, called vector autoregression, measure direct impulse-response patterns and feedbacks. An application to the well-known Vostok ice core data revealed an error in Al Gore’s documentary *An Inconvenient Truth*. Gore showed the data and drew attention to the coherence of temperature and CO₂ changes over a 440,000 year span, which he asserted was due to CO₂ driving temperature changes. But temperature changes can also affect atmospheric CO₂ levels. Davidson et al. (2015) examined the series and found that temperature Granger causes CO₂ but not the reverse. In other words on the time scales represented in the Vostok data the coherence in the series is primarily due to the influence of temperature on CO₂ levels not the feedback of CO₂ levels on temperature.

In summary, the primary statistical methods for attributing causation in climate data are optimal fingerprinting and time series analysis. Applications of the Allen and Tett (1999) optimal fingerprinting method dominate the attribution literature and have underpinned past IPCC conclusions, but results depend on the accuracy of climate models and the method has recently been criticized as inherently biased. Time

series methods do not depend on climate models but require assumptions of their own and have generated results that have thus far not converged on a consensus.

8.4 Declining planetary albedo and recent record warmth

A sharp recent increase in global average temperatures has raised the question of short-term drivers of climate. One such candidate is the fraction of absorbed solar radiation which has also changed abruptly in recent years. The question to be answered is whether the change is an internal feedback to warming caused by greenhouse gases or whether something else changed the fraction of absorbed radiation which then caused the recent warming.

The albedo is the fraction of incoming solar radiation that is reflected back into space rather than being absorbed by the planet. Highly reflective surfaces like cloud tops and snow and ice are most important in this regard. The Earth's albedo is approximately 30%, meaning almost a third of the sunlight that reaches Earth is directly reflected back to space. A lower albedo implies more solar energy is absorbed by the planet to be then re-radiated as heat. Hence, other things being equal, a decline in albedo is associated with a warming of the Earth.

Arguably the most striking change in the Earth's climate system during the 21st century is a significant reduction in planetary albedo since 2015, which has coincided with at least two years of record global warmth. Figure 8.1 shows the planetary albedo variations since 2000, when there are good satellite observations. The 0.5% reduction in planetary albedo since 2015 corresponds to an increase of 1.7 W/m² in solar energy averaged over the planet (Hansen and Karecha, 2025). For comparison, the IPCC estimate of forcing from the increase in atmospheric CO₂ compared to preindustrial times is approximately 2.2 W/m² (Figure 3.1.2).

Looking back prior to 2000 with less adequate data, Gossling et al. (2025) assessed that planetary albedo was relatively low around the 1940's and 50's, before rising industrial aerosol precursor emissions increased albedo until the 1980's. The strongest planetary albedo excursions were high-albedo episodes caused by volcanic eruptions, such as after the Mount Pinatubo eruption in 1991. Although uncertain, the 2023 planetary albedo minimum may have been the lowest since at least 1940.

Changes in surface characteristics can't explain this decrease in planetary albedo since 2015:

- Arctic sea ice extent has declined by about 5% since 1980 (https://nsidc.org/data/seaice_index/images/s_plot_hires.png), although following 2007 there has been a pause in the Arctic sea ice decline (England et al., 2025)
- Regarding Antarctic sea ice, the IPCC AR6 concludes that “There has been no significant trend in Antarctic sea ice area from 1979 to 2020 due to regionally opposing trends and large internal variability.” (Summary for Policymakers, A.1.5)
- Northern hemispheric annual snow cover has been slowly declining since 1967, with barely significant trends. The data show the Northern Hemisphere has snowier winters, accompanied by more rapid melt in spring and summer. <http://climate.rutgers.edu/snowcover/>
- Global greening (Chapter 2) is contributing to the decrease in planetary albedo, as forests have a lower albedo than open lands or snow. However, there is some evidence that forests increase cloud cover (high reflectivity), which counteracts the direct albedo increase associated with increasing forested area.

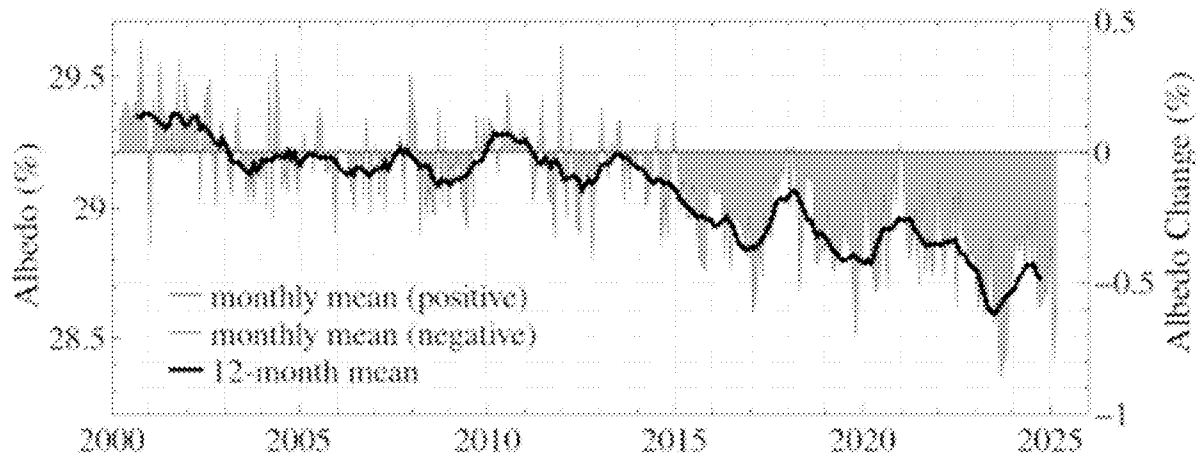


Figure 8.1. Earth’s albedo (reflectivity, in percent), with seasonality removed. From Hansen and Karecha (2025)

Changes in surface reflectivity are contributing to a small, slow decline in planetary albedo. However, these changes cannot explain the sharp decline in planetary albedo beginning in 2015. Further, any changes in surface albedo are effectively damped by about a factor 3 on average, primarily due to cloud masking (Loeb et al. 2019). Surface albedo changes have thus contributed only weakly to the recent planetary albedo decline, particularly when averaged annually and globally.

This leaves the most likely explanation for the sharp albedo decline as changes in atmospheric aerosols and/or clouds.

Aerosols are small particles in the atmosphere that reflect sunlight and can interact with cloud processes to make the clouds more reflective. Aerosols have both natural origins (e.g dust from soils, wildfires) as well as human origins from combustion (including fossil fuels). Regions that are greening and/or have an increase in rainfall may be producing less dust. For anthropogenic aerosols, new ship fuel regulations aimed at reducing sulfur emissions were implemented in three phases, in 2010, 2015 and 2020. Sulfate particles reflect solar radiation. Cleaner air means less solar radiation is reflected, which contributes to surface warming. Indirect effects of sulfate aerosols include increasing the reflectivity of low-level clouds in the subtropics. There is controversy surrounding the importance of this change in sulfate emissions to the Earth’s radiation balance (Hodnebrog et al., 2024; Yuan et al., 2024), but the restriction of this effect to major shipping routes suggests a small global impact (Schmidt, 2024).

This leaves changes in clouds as the primary candidate to explain the decline in global albedo since 2015. Two recent papers (Loeb et al., 2024; Goessling et al 2024) have addressed recent variations in cloud properties. By considering satellite and reanalysis data, Loeb et al. found that decreases in low and mid-level clouds since 2015 are the primary reason for decreasing planetary albedo in the Northern hemisphere, whereas in the Southern hemisphere the decrease in planetary albedo is primarily due to decreases in mid-level clouds across all latitude zones. Goessling et al. (2024) found that cloud anomalies were mainly due to reduced low-level clouds. Regions with coherent low-level cloud reductions over the past decade include the warm pool region around the Maritime Continent and the northern extratropical western Pacific, as well as large parts of the Atlantic and adjacent land regions. The reduction of global cloud cover identified in these analyses since 2015 is 1-2 percent.

The question then becomes what caused the change in cloud cover. Two causes have been posited for the declining cloud cover over the past decade:

- Natural climate variability
- Changes in low cloud cover associated with warming sea surface temperatures, implying an emerging positive feedback to climate change (Hansen and Karecha, 2025)

The existence of a new positive low cloud feedback that began emerging in 2015 is not easy to justify. However, there are numerous natural climate signals during this period that are associated with atmospheric circulation changes that can influence the distribution of clouds:

- The 2014-2016 was the strongest El Nino event on record
- A cold anomaly beginning in 2015 in the subpolar gyre of the North Atlantic reflects a shift in the ocean circulation pattern associated with decadal variability in the Atlantic (Frajka-Williams et al., 2017; Arthun et al. 2021).
- The Pacific Decadal Oscillation (PDO) positive index peaked in 2016, then declined and has been in negative territory since late 2019
- Eruption of the submarine Hunga-Tonga volcano in 2022

Interannual cloud anomalies associated with the El Nino Southern Oscillation (ENSO) have a significant global signal and strong regional signals especially over the tropical Indian and Pacific Oceans.

The Hunga Tonga eruption is remarkable in its coincidence with the exceptionally low value of planetary albedo in 2023. Goessling et al. (2024) found that the cloud perturbations in 2023 showed a different pattern from the overall pattern since 2015, with reduced cloud cover being most pronounced in the northern hemisphere and tropics. Regional reductions in cloud cover were most pronounced over the eastern Indian Ocean, over South America and extending over the eastern Pacific, as well as over northern North America, in the Southern Ocean around 60S, in the subtropical and eastern North Atlantic, and in parts of the North Pacific.

The Hunga Tonga eruption was unusual in that it injected large amounts of water vapor into the stratosphere, in addition to sulfate particles. Early publications focused on the impacts to stratospheric circulations and the direct radiative impact. In 2025, papers are emerging that examine the indirect effects of Hunga Tonga on surface climate using ensemble simulations from earth system models (Bednarz et al, 2025; Kuchar et al., 2025). These papers found statistically significant impacts on regional climates that were driven by circulation changes from couplings between the stratosphere and troposphere. These papers indicate the complex interactions between volcanic activity and climate dynamics. More research is needed to untangle any impacts of Hunga Tonga eruption on planetary albedo.

In summary, the decline in planetary albedo and the concurrent decline in cloudiness have emphasized the importance of clouds and their variations to global climate variability and change. A change of 1 to 2 percent in global cloud cover has a greater radiative impact on the climate than the direct radiative effect of doubling CO₂. While it is difficult to untangle causes of the trend, the competing explanations for the cause of the declining cloud cover have substantial implications for assessing the Equilibrium Climate Sensitivity and also the attribution of the recent warming. An additional 10 years of data should help clarify whether this is a strong positive cloud feedback associated with warming, or a temporary fluctuation driven by natural variability

8.5 Attribution of climate impact drivers

The IPCC (Ranasinghe et al. 2021) defines “climate impact drivers” or CIDs as “physical climate system conditions (e.g., means, events, extremes) that affect an element of society or ecosystems.” Hence CIDs are those features of the weather and climate system of primary interest in assessing the impacts of climate change since they potentially affect humans and the natural world. For instance, under the heading “Heat and Cold” CIDs are identified as mean air temperature, extreme heat, cold spells and frost. The IPCC also points out that CIDs are not necessarily harm-related: depending on the system in question they can be detrimental, neutral, beneficial or a combination.

The first column of Table 12.12 in Ranasinghe et al. (2021, p. 1856), reproduced here as Table 8.1, summarizes the AR6 assessment of whether a signal of attributable anthropogenic influence has emerged across all major CIDs. One of the themes of this chapter is that attribution methods used by the IPCC tend to overstate the anthropogenic influence and understate the role of natural variability. Nonetheless a striking feature of that summary table is how few CIDs exhibit an anthropogenic signal sufficient to distinguish them from natural variability.

Out of the 33 weather impact categories an anthropogenic signal is asserted with *high confidence* in only five, and with *medium confidence* in a further four. (Note that one of the CIDs is an increase in CO₂ levels, and since it is a tautology to attribute this to increased CO₂ levels this CID can be ignored.) For the rest the IPCC does not claim to have detected anthropogenic drivers. Of the five *high confidence assertions*, two are for changes in average temperatures (air and ocean) hence are not measures of extreme weather. Also two of the four *medium confidence* assertions are related to ocean chemistry and thus are likewise not related to extreme weather. The IPCC does not assert a human influence on many non-temperature weather features such as wind, precipitation, flooding, drought etc.

Columns 2 and 3 of IPCC Table 12.12 report on whether anthropogenic signals are expected to emerge this century under RCP8.5, the most extreme forcing scenario. We have omitted these columns for several reasons. First, because they refer to whether climate models project detectable signals in the observations, which is a very different question than our concern here, whether a signal has been detected in historical data. Second, as we discuss in Chapter 4, the RCP8.5 scenario is a misleading and implausible high-end storyline, it is not a “base case” or business-as-usual projection. Third, the ensemble of detailed models is acknowledged (Palmer and Stevens 2019) to be “not fit for purpose” in describing regional changes and “unable to represent future conditions at the degree of spatial, temporal, and probabilistic precision with which projections are often provided.” (Nissan et al, 2019)). Even with these caveats, we note that the omitted columns in AR6 Table 12.12 indicate most weather impacts are not expected to exhibit an anthropogenic signal this century.

Climatic Impact-driver Type	Climatic Impact-driver Category	Already Emerged in Historical Period
Heat and Cold	Mean air temperature	1
	Extreme heat	2
	Cold spell	4
	Frost	
Wet and Dry	Mean precipitation	
	River flood	
	Heavy precipitation and pluvial flood	
	Landslide	
	Aridity	
	Hydrological drought	
	Agricultural and ecological drought	
	Few weather	
Wind	Mean wind speed	
	Severe wind storm	
	Tropical cyclone	
	Sand and dust storm	
Snow and Ice	Snow, glacier and ice sheet	
	Permafrost	
	Lake, river and sea ice	11
	Heavy snowfall and ice storm	
	Hail	
	Snow avalanche	
Coastal	Relative sea level	
	Coastal flood	
	Coastal erosion	
Open Ocean	Mean ocean temperature	
	Marine heatwaves	
	Ocean acidity	
	Ocean salinity	13
	Dissolved oxygen	14
Other	Air pollution weather	
	Atmospheric CO ₂ at surface	
	Radiation at surface	

High confidence of decrease

Medium confidence of decrease

Low confidence in direction or change

Medium confidence of increase

High confidence of increase

Table 8.1: Reproduction of column 1 of Table 12.12, IPCC AR6 Working Group I report. Emergence of anthropogenic signal in historical period for CIDs shown. White: no signal detected. Blue and orange: change detected (decrease or increase) and confidence level as indicated in color legend.

As we discussed in Chapter 7 natural variability dominates patterns of extreme weather systems and simplistic assertions of trend detection are frequently undermined by regional heterogeneity and trend reversals over time. Table 8.1 makes the related point that, again contrary to popular belief, attribution of changes in most extreme weather types to human influence is not currently possible. Taking wind as an example, the IPCC claims that an anthropogenic signal has not emerged in average wind speeds, severe windstorms, tropical cyclones or sand and dust storms, nor is one expected to emerge this century even under an extreme emissions scenario. The same applies to drought and fire weather.

Nissan <https://wires.onlinelibrary.wiley.com/doi/10.1002/wcc.579>

8.6 Extreme event attribution (EEA)

Examining the IPCC’s treatment of extreme weather and climate event attribution more broadly, the AR6 provides an ambiguous assessment of the role of anthropogenic warming that differs between chapters. Chapter 11 of WG1 states (Seneviratne et al., 2021):

“Evidence of observed changes in extremes and their attribution to human influence (including greenhouse gas and aerosol emissions and land-use changes) has strengthened since AR5, in particular for extreme precipitation, droughts, tropical cyclones and compound extremes (including dry/hot events and fire weather). Some recent hot extreme events would have been extremely unlikely to occur without human influence on the climate system.”

By contrast, as noted above, Chapter 12 of WG1 (Table 12.12) paints a different picture – presumably, the expert judgment of different groups of authors for the two chapters came to different conclusions (Ranasinghe, 2021):

- High confidence in an increase in extreme heat events in tropical regions where observations allow trend estimation and in most regions in the mid-latitudes, medium confidence elsewhere
- Medium confidence in a decrease in extreme cold events in Australia, Africa and most of northern South America where observations allow trend estimation
- No evidence of emergence in the historical period of a change in river floods, heavy precipitation, drought, fire weather, severe wind storms, and tropical cyclones

While the overall issue of detecting changes in extreme weather events and their attribution remains ambiguous, most of the activity in this area relates to the attribution of particular extreme weather events. The most prominent effort is World Weather Attribution (WWA; worldweatherattribution.org), an international research initiative for extreme event attribution that purports to analyze how climate change influences the likelihood and intensity of extreme weather events. Their approach is to use large ensembles of regional climate models to compare the event in today’s climate with a counterfactual pre-industrial climate without human influences.

WWA has a prominent public presence in linking extreme weather to climate change, with its press releases attracting considerable attention in public and policy discussions. However, the WWA’s extensive promotion of non-peer-reviewed findings, its funding ties, its open admission to shaping analyses to serve litigation, and its methodological challenges have sparked controversies, with critics questioning the robustness and impartiality of their conclusions (Pielke Jr. 2024). Despite these issues, WWA’s work continues to influence climate science and media narratives. Technical criticisms of the approach include a

lack of a formal detection process; an implicit assumption that 100% of the post-industrial warming is caused by greenhouse gases; and a failure to adequately account for internal climate variability.

Because EEA is relatively new many basic methodological issues have yet to be settled in the expert literature. An important challenge is the lack of data. Extreme events are by definition rare. Many analyses of extreme event types (including the US National Assessment Reports) only evaluate data since 1950 or 1970. However, as emphasized by Chapter 7, many of the worst extreme weather and climate events in U.S. history occurred prior to the first half of the 20th century including in the early 19th century. And if paleoclimate reconstructions are considered, it becomes very difficult for an event to pass the detection thresholds of exceeding what is expected from natural variability, particularly if a reasonably sized geographic region is considered.

Another challenge is defining the event under study. There is a longstanding literature in statistics and econometrics on the challenge of analyzing data with outliers. The issue arises because a data series establishes a probability distribution defining the expected range of observations. If an outlier is observed it might indicate that the underlying process giving rise to the data distribution has changed (which in the weather context would mean that a climate change has been detected) or that the underlying process has multiple regimes each with a different probability distribution, in which case observing an outlier simply means we were temporarily in a different regime, but the system itself was unchanged. If a time series contains only a single outlier event at the end of the series it is not possible to determine which model is the correct one (Chen and Liu 1993). For instance, there might be an “ordinary” weather regime that yields a distribution of summer daytime highs in a particular coastal region, and a second “heatwave” regime that kicks in when an inland blocking event occurs, which yields a temperature distribution centered 15°C higher than the first one. A day with temperatures 13°C above normal would either be an extreme heat anomaly under the first regime or a somewhat cool event under the second, and we have no way in this case of knowing on statistical grounds which view is correct.

Visser and Petersen (2012) and Sardeshmukh et al. (2015) both point out that different distributions may fit observed data equally well but yield very different implications about the likelihood of a specific weather event. Visser and Petersen argue that, in view of the deep uncertainties of extreme weather analysis drawing a connection between individual events and global climate change should be avoided. Furthermore, the existence of an outlier at the end of a data series poses the problem that estimates of the event probabilities will be biased whether the outlier is included or excluded (Barlow et al., 2020). Methods to eliminate the bias have not yet been established, leading some experts (e.g. Miralles and Davison 2023) to argue that in settings in which a data series contains a single extreme event at the end, estimation of a return period for the extreme event will be so biased and uncertain it should be avoided altogether.

In spite of these concerns, the U.S. is presently considering something like the WWA, which is being investigated by a NASEM Panel on Attribution of Extreme Weather and Climate Events and their impacts (NASEM, 2025).

We provide a case study of a recent high impact extreme event in the U.S. to illustrate the challenges and ambiguities in attributing the frequency and intensity of extreme weather events to human-caused warming.

8.6.1 Case study – 2021 Western North America heat wave

The 2021 Western North America heat wave was an extreme event that affected much of Western North America in late June 2021. In particular, surface temperature records were set in Portland, OR (116°F; previous record 107°F) and Seattle, WA (108 °F; previous record 103°F) (Mass et al., 2024).

The WWA team generated international headlines with their analysis, which provided the following attribution statements (WWA, 2021; Philip et al., 2022):

- Based on observations and modeling, the occurrence of this heatwave was virtually impossible without human-caused climate change.
- The event is estimated to be about a 1 in 1000-year event in today's climate.
- The event would have been at least 150 times rarer without human-induced climate change.
- This heatwave was about 2°C hotter than it would have been if it had occurred at the beginning of the industrial revolution (when global mean temperatures were 1.2°C cooler than today).

But an important counter to the first claim is that other researchers concluded from historical weather data that while a heat wave of the magnitude observed was indeed virtually impossible without anthropogenic climate change, it was also virtually impossible *with* climate change. Bercos-Hickey (2022) noted “these temperatures were virtually impossible under any previously experienced meteorological conditions, with or without global warming.” McKinnon and Simpson (2022) stated “the most likely explanation remains that the weather event itself was ‘bad luck.’” The 2023 Oregon Climate Assessment (Fleischman, 2023) concluded that the heat dome would have formed even without climate change and “There is no evidence that the highly unusual combination of weather features that drove the heat dome were made more likely by climate change, and climate models do not project an increase in the frequency of high-pressure ridges over the Pacific Northwest” (Fleischman, 2023, p. 49).

Mass et al. (2024) summarizes the proximate sequence of compound events leading to the heat wave. There was a record-breaking mid-tropospheric ridge over the Pacific Northwest, forced by a tropical disturbance in the western Pacific. This produced record-breaking mid-tropospheric temperatures, strong subsidence in the lower atmosphere, low-level easterly flow that produced downslope warming on regional terrain and the removal of cooler marine air, and an approaching low-level trough that enhanced downslope flow. The event occurred at a time of maximum solar insolation, and drier-than-normal soil moisture. Using a storyline approach, Mass et al. assessed that there is no trend in drought and dry soils in the Pacific Northwest; there is no evidence of global warming producing stronger ridges of high pressure, and no observed trend in heat waves or record temperatures in the region. They concluded that although anthropogenic warming may have contributed as much as 2°F to the magnitude of the event, there is little evidence of further amplification of the event from increasing greenhouse gases.

Bercos-Hickey et al. (2022) conducted a statistical analysis of a model-based attribution study of this heat wave. Because the event is a far outlier and far above the bounds of Generalized Extreme Value distributions fitted from historical data, they concluded that estimates of return times, quantitative changes in event magnitude and frequency, and probability of the extreme temperatures such as provided by the WWA are not accurate and should be interpreted as having low confidence. They found that hindcast attribution methods using an ensemble of regional climate models, combined with Pearl (2009) causal inferences, can provide limited and conditional information about the magnitude of the human influence on this heatwave - they provided a more highly constrained estimate that human activities caused a ~1.4°C–1.8°F increase in the daily maximum temperatures.

Zeder et al. (2023) also concluded that the methods employed by Philip et al. (2022, the WWA analysis) tend to overstate the rarity of extreme heat waves, leading to a biased perception of the effect of climate change on the heatwave event: “The tendency to overestimate the return period of observed extreme heatwave events may fuel the impression that seemingly impossible heatwave extremes are currently clustering at an unprecedented rate.”

The 2021 Western North America heatwave was a rare and unprecedented compound weather event that broke century-old temperature records by as much as 9°F. While the WWA team received worldwide publicity for their rapid attribution claims blaming anthropogenic climate change, subsequent peer-reviewed analyses showed that the event was caused by rare meteorological conditions that were not made more probable by global warming.

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PART III: IMPACTS ON ECOSYSTEMS AND SOCIETY

9 CLIMATE CHANGE AND US AGRICULTURE

Chapter summary

There is abundant evidence going back decades that rising CO₂ levels benefit plants, including agricultural crops, and that CO₂-induced warming will be a net benefit to US agriculture. The warming since 1981, in combination with adaptive behavior by farmers, has been beneficial for maize. The increased ambient CO₂ has also boosted productivity of all major US crop types. Various attempts to argue that CO₂-induced warming will harm agriculture do not hold up under scrutiny.

9.1 Econometric analyses

Econometric analyses of the effects of climate change on agriculture have sought to integrate information about long term crop yield changes in response to temperature and precipitation changes under assumptions about adaptive behavior by farmers. One method focuses on variations in agricultural land values. The rationale is that if climate change is a long-term net benefit for agriculture it should be capitalized into higher market values for agricultural land, and vice versa. While individual crops might benefit from or be harmed by climate change, once the adaptive responses of farmers are considered the value of farmland represents an index of whether the changes are expected to be beneficial or not. Mendelsohn et al. (1994) examined the relationship between historical climatic variations on agricultural land values and concluded global warming would be slightly beneficial to American agriculture.

The Mendelsohn et al. method, called Ricardian analysis after David Ricardo, the 19th century British economist who pioneered the study of land values, attracted subsequent criticism from authors who argued it failed to account for differences in land values attributable to fixed locational characteristics like soil quality, and non-climatic changes including nearby urbanization. Deschênes and Greenstone (2007) looked at agricultural profits instead of land values and reached conclusions similar to Mendelsohn et al. (1994), namely that past climatic variations had relatively little effect on farm profitability and that warming would likely yield small overall benefits for the US agricultural sector. However, a subsequent exchange with critics led them (Deschênes and Greenstone 2012) to revise their conclusions and project potentially large losses in US agriculture due to climate warming.

Burke and Emerick (2016) looked at temperature variations over 1980 to 2000 and argued that farmers were not as able to adapt to temperature changes as the Ricardian method assumes and that climate change would have large negative impacts on corn and soy yields. Schlenker and Roberts (2009) similarly argued that yield gains to past warming would not carry over to the future and corn and soy yields would sharply decrease this century due to climate change.

Two recent studies have argued that pessimistic findings such as these are not robust. Ortiz-Bobea (2019) argued that land values aggregate farm and non-farm influences and the latter need to be filtered out. He developed a data set using cash rents for agricultural activity as a measure of land value specifically for farming activity. Whereas the land value model implied future losses under climate warming, the same model estimated using cash rents did not, leading the author to conclude the pessimistic results were due to using an inaccurate measure of the returns to farming activity. Bareille and Chakir (2023) assembled a large data base on farm sale prices in France for properties that sold twice between 1996 and 2019. They could replicate pessimistic results showing negative effects of warming on agricultural land values using conventional econometric modeling. But by taking advantage of the repeat sales data, which provides information on site-specific changes in land prices, they found the results reversed and implied that climate change will be very beneficial for French agriculture. The authors concluded that, taking adaptation into account, a warming climate would yield positive benefits for French agriculture that were between two and

20 times larger than had previously been estimated. On average, with full adaptation, they concluded that climate changes under the medium RCP4.5 scenario could double the value of French farmland by 2100.

A major deficiency of all these studies, however, is that they omit the role of CO₂ fertilization. Climate change as it relates to this report is caused by GHG emissions, chiefly CO₂. The econometric analyses referenced above focus only on temperature and precipitation changes and do not take account of the beneficial growth effect of the additional CO₂ that drives them. As explained in Chapter 2 CO₂ is a major driver of plant growth, so this omission biases the analysis towards underestimation of the benefits of climate change to agriculture.

9.2 Field studies of CO₂ enrichment

One of the ways the effect of CO₂ on crop growth has been studied is through “free air enrichment experiment” or FACE plots, in which small sources of CO₂ are placed in fields surrounding plants and the growth response to elevated CO₂ under varying weather conditions are recorded. Ainsworth et al. (2020) summarizes results from about 250 such studies. They found that elevation of CO₂ by 200 ppm caused an average 18% increase in crop yield in C3 plants. C4 plants exhibited benefits mainly under drought conditions.

In addition to FACE plot experiments there have been thousands of laboratory experiments on the effects of CO₂ on all kinds of plant growth. Here we review some of the results on key US agricultural crops.

Soybean

Studies on the impact of elevated CO₂ on Soybean (*Glycine max* (L.) Merr.) plants in the water-deficient region of Huang-Huai-Hai Plain, China, showed that elevated CO₂ concentrations improved photosynthesis rate, water use efficiency, and growth Li (2013) under both normal conditions and drought conditions. The CO2Science.org website reports on 108 published experiments between 1985 and 2019 exposing soybean to enriched CO₂ levels. Converted to a +300ppm common scale the average growth benefit was +50.9 percent. There were also ten studies reporting on +600 ppm CO₂ enrichment, which increased photosynthesis by an average of 90.3%.

Maize (corn)

The CO2Science.org website reports on 28 published experiments between 1983 and 2018 exposing corn (*Zea mays* L.) to enriched CO₂ levels. Converted to a +300ppm common scale the average growth benefit was +23.7 percent. Corn also benefits from increased drought tolerance under elevated CO₂. An experimental study (Allen Jr., 2011) exposed plants to water stress conditions in sunlit controlled-environment chambers at 360 ppm (ambient) and 720 ppm (elevated) CO₂. The drought stress caused a 41% loss of growth under ambient CO₂ but only a 13% loss under elevated CO₂.

Wheat

The CO2Science.org website reports on 92 published experiments between 1983 and 2020 exposing common wheat (*Triticum aestivum* L.) to enriched CO₂ levels. Converted to a +300ppm common scale the average growth benefit was +67.6 percent. Blandino (2020) measured both the yield and nutritional quality of an “improver” hybrid wheat variety and its parents under elevated CO₂ levels (+166 ppm). They reported

a grain yield increase of +16% but a 7% decrease in grain protein levels. But they found that the food quality of different wheat varieties responded differently to elevated CO₂ levels, so that with proper varietal selection, growers could select wheat types that best take advantage of the elevated CO₂.

Further evidence

A 2021 report from the US National Bureau of Economic Research (Taylor and Schlenker 2021) used satellite-measured observations of outdoor CO₂ levels across the United States, matched to county-level agricultural output data and other economic variables. After controlling for the effects of weather, pollution and technology the authors concluded that CO₂ emissions had boosted U.S. crop production since 1940 by 50 to 80 percent, attributing much larger gains than had previously been estimated using FACE experiments. They found that every ppm of increase in CO₂ concentration boosts corn yields by 0.5 percent, soybeans by 0.6 percent, and wheat by 0.8 percent.

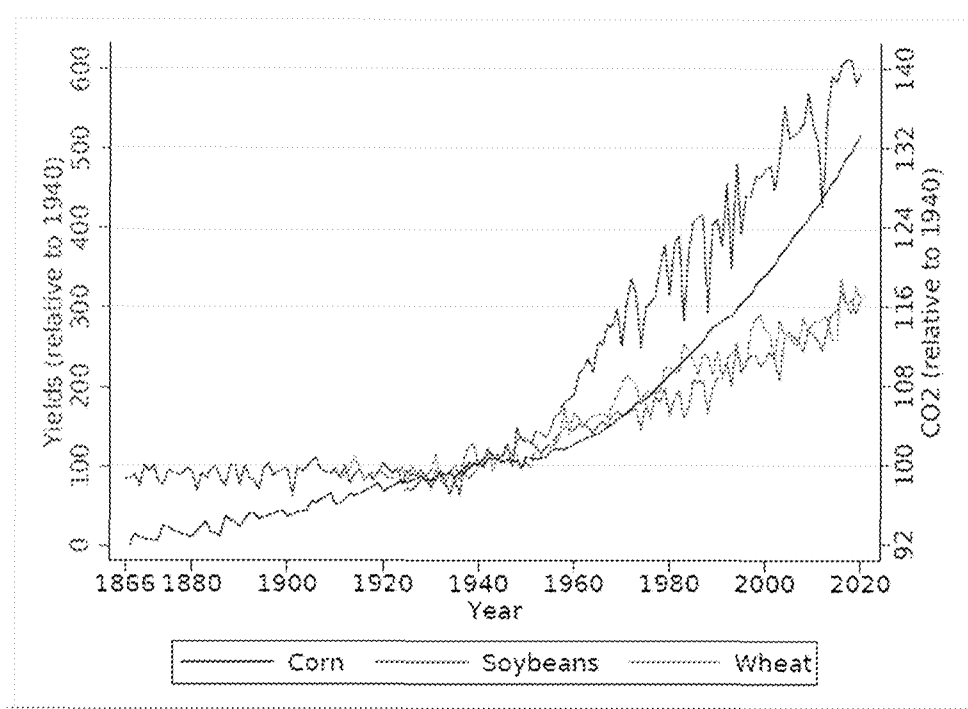


Figure 9.1: US average CO₂ levels and yields of corn, soy and wheat all normalized so 1940=100.
Source: Taylor and Schlenker (2021)

Beyond growth benefits, extra CO₂ boosts plant resilience to dryness. Derying et al. (2016) surveyed evidence on crop water productivity (CWP, the yield per unit of water used), drawing attention to the potential for CO₂ both to enhance photosynthesis and reduce leaf-level transpiration (water loss during leaf respiration). They surveyed all available FACE data on crop yield changes for Maize (corn), Wheat, Rice and Soybean, and combined it with crop model data simulating yield responses as of 2080 under the extreme RCP8.5 scenario in four growing regions (Tropics, Arid, Temperate and Cold) each of which were split into rainfed and irrigated sub-regions. In every region they reported that models without CO₂ fertilization predicted CWP losses but CO₂ fertilization more than offset them; once fertilization was taken into account,

all regions showed a net CWP gain. Deryng et al also reported that negative yield impacts on wheat and soybean were fully offset by CWP gains, and mitigated by up to 90% for rice and 60% for maize.

Similar to this, Cheng et al. (2017) noted that increased global plant growth from 1982 to 2011 due to rising CO₂ uptake was accompanied by such large gains in CWP that despite the extra biomass global water use by plants had not increased.

Deryng et al. (2016) assumed that climate change would “exacerbate water scarcity”. It is noteworthy that while models predict drylands will expand under climate warming, observations show the opposite: greening is happening even in arid areas. Zhang et al. (2024) report that due to increased CO₂ levels “increasing aridity in drylands won’t lead to a general loss of vegetation productivity”; increased desertification will happen in at most 4% of currently arid areas.

9.3 Crop modeling meta-analyses

Notwithstanding the abundant evidence for the direct benefits of CO₂ and of CO₂-induced warming on crop growth, in 2023 the US Environmental Protection Agency (EPA 2023) boosted its estimate of the Social Cost of Carbon (SCC) about five-fold based in large part on a very pessimistic 2017 estimate of global agricultural damages from climate warming (Moore et al., 2017). One of the two damage models used by the EPA attributed nearly half of the 2030 SCC to projected global agricultural damages based on the Moore et al. (2017) analysis. This study was a meta-analysis of crop model studies simulating yield changes for agricultural crops under various climate warming scenarios. Moore et al. projected declining global crop yields for all crop types in all regions due to warming.

McKittrick (2025) re-examined the Moore et al. database and found that, while it claimed to cover 1,722 studies, only half the entries ($N=862$) had complete records, so that the sample available for regression analysis was much smaller than both studies indicated. McKittrick noted that the variable most commonly missing was the change in ambient CO₂ and found that in many cases these could be recovered from the underlying studies or the original climate scenario tables. He thereby increased the usable sample size by 40 percent. The crop yield projections incorporating the newly available data changed considerably. As shown in Figure 10.2, whereas the partial data set implied warming would decrease yield (blue lines), the complete data set implied constant or increase global yields, even out to 5°C warming (green lines).

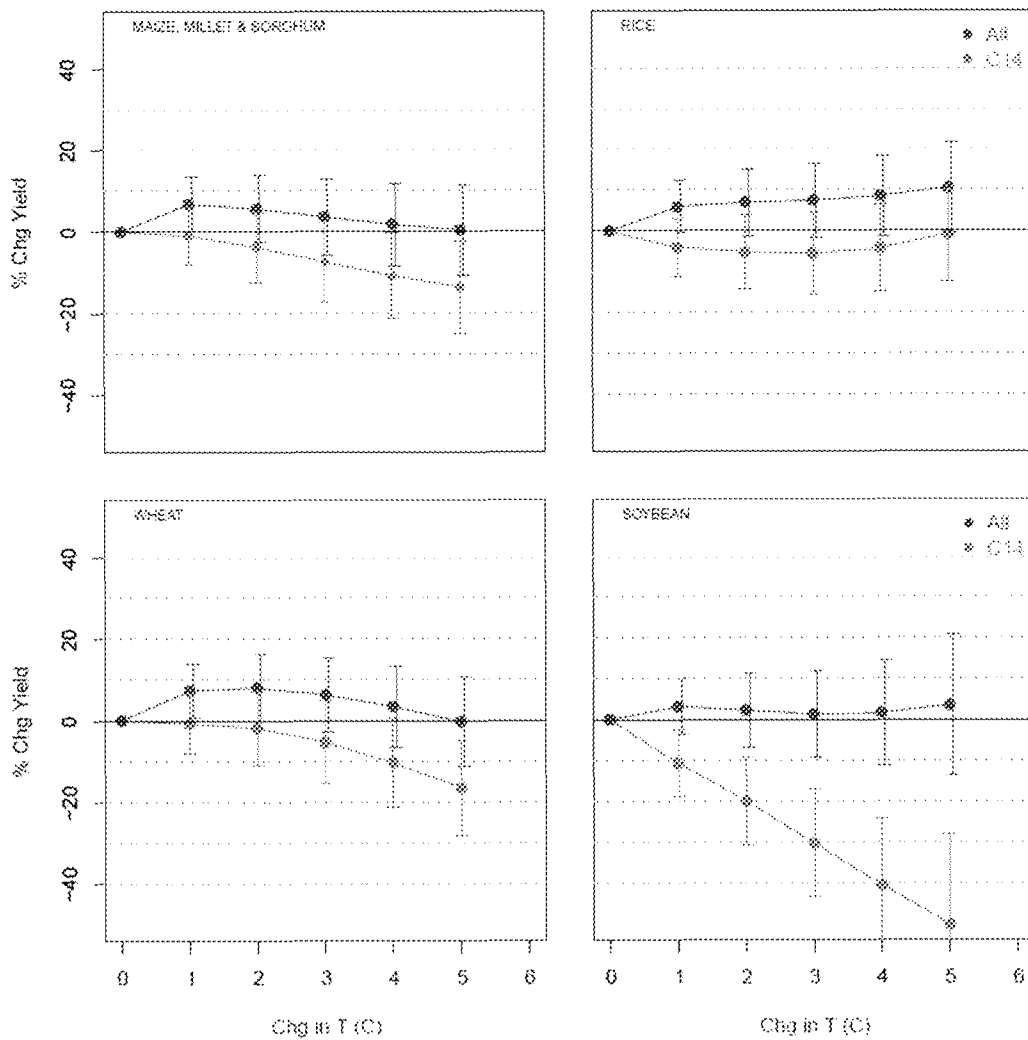


Figure 9.2 Crop yields under CO₂-induced climate warming. Blue: as published in Moore et al. (2017). Green: after including omitted data. Source: McKittrick (2025).

In summary, there is abundant evidence going back decades that rising CO₂ levels benefit plants including agricultural crops, and that CO₂-induced warming will be a net benefit to US agriculture.

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